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## ANNUAL INVESTIGATIVE REPORT FOR 1927 AND

## PROGRAM FOR 1928

## APPALACHIAN FOREST EXPERIMENT STATION

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# INVESTIGATIVE REPORT FOR 1927 AND PROGRAM FOR 1928.

## APPALACHIAN FOREST EXPERIMENT STATION

ASHEVILLE, N. C.

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This is the seventh annual report of the Appalachian Forest Experiment Station. Previous reports have dealt chiefly with the activities of the past calendar year and the plans immediately ahead. The present report, after briefly outlining the field of investigations, traces the development of each of the major lines of work from its beginning, so that the present status of the investigations will be more clearly understood. The trend of the future activities of the Station will then be discussed, followed by specific recommendations for the work during the calendar year 1928.

### Purpose and Field of the Appalachian Station

The general purpose of the Appalachian Station, like that of the other regional forest experiment stations maintained by the U. S. Forest Service, is to obtain the basic information necessary for timberland management. Forests are the natural cover of most of the non-agricultural land in the Station's territory. Their productive management is a matter of private interest as well as of public economy for many reasons. One is the production of timber, as a crop, on lands generally unsuitable for agriculture. Another is the protection of stream watersheds against excessive run-off, erosion, and the silting-up of stream channels and power reservoirs. Still another object of management is the maintenance of game and fish. In the Southern Appalachian region these three objects - timber production, control of the water run-off, and game maintenance - are closely related and all three will often affect the management of a single tract of timberland. Their harmonious development will be a problem of increasing importance in the land management of the region.

### Forest Conditions and Problems

TERRITORY. The Station's territory now includes the States of Virginia, West Virginia, North Carolina, eastern Kentucky, and Tennessee, South Carolina and northern Georgia and Alabama. The State of Maryland, formerly in the Appalachian Station's territory, has become part of that of the newly organized Allegheny Forest Experiment Station, while South Carolina has been assigned to the Appalachian Station. The field of work of the Appalachian Station thus becomes about 120,000,000 acres of which about 76,000,000 acres are actual or potential forest. The Appalachian Mountain system forms the backbone of the region. West of this and separated from it by the Shenandoah and Tennessee Valleys (collectively known as the Appalachian Valley) are the Alleghany and Cumberland Highlands of West Virginia, Kentucky, and Tennessee. East of the Appalachian ranges is the Piedmont Plateau, and still farther east is the Coastal Plain.

FOREST COVER. The forest cover of the mountains and highlands, including much of the Piedmont Plateau, is predominantly of hardwoods. About one-fourth of the entire hardwood forest area of the United States is found here, and the unusual advantages of the Southern Appalachians for timber growing give this fact special

significance for the future production of hardwoods in this region. Among the hardwoods, however, softwood species are rather plentifully distributed, contributing to the variety and value of the forest. These softwoods are mostly pines and hemlock, with spruce and fir capping the highest peaks and ridges in West Virginia, Virginia, North Carolina, and Tennessee. East of the mountains pines become more important. On the Coastal Plain the rapidly growing loblolly pine forms the characteristic pine forest. Its stands are interspersed and bordered with estuary and coastal swamps of hardwoods, cypress, and southern white cedar.

OWNERSHIP OF TIMBERLANDS. Nine National Forests, aggregating about 1,762,000 acres, comprise about 3.2 per cent of the total forest area. Except for a few thousand acres under management as State forests and parks, the remainder of the forest area is privately owned. About 28,000,000 acres are in small timber tracts or wood-lots on farms. The timber of the Piedmont Plateau is wholly farm woods which are small and isolated. Larger privately owned tracts comprise probably 15,000,000 acres in the mountains and 9,000,000 acres on the Coastal Plain.

NATIONAL PARKS. Two areas of several hundred thousand acres are now being considered for national parks. One of these is in the Blue Ridge Mountains of Virginia, and consists of hardwood forest land. The other is in the Smoky Mountains and includes a considerable part of the remaining stand of virgin spruce and fir timber.

LACK OF STATISTICAL INFORMATION. As to the amount of remaining virgin timber, the areas lightly culled and heavily cut-over, actively reproducing and not reproducing, burned and unburned, there are unfortunately no statistics. This lack of information of the condition of the forests seriously interferes with any broad conception of the problems and region-wide plans for their solution. As will be shown later the Appalachian Station is attempting to get at the conditions prevailing on the cut-over areas by means of detailed surveys; but with the resources at present available the results can be only fragmentary. What is needed for the region is a general survey of the timberland resources. Until this is done the prevailing conditions can not be expressed quantitatively except as estimates.

VIRGIN TIMBER AND SECOND-GROWTH. There are probably less than 3,000,000 acres of timberland that could be classed as virgin or even as lightly culled old-growth at all comparable with the original forest. Probably most of this has been culled for its best timber, and much of it is in small patches in the less accessible cove heads. Much the greater part of the forest has been heavily culled. Large areas have been cut over several times, part of the original stand being removed at each cutting. A second growth has followed these cuttings, but its development has commonly been impeded by unmerchantable old trees left standing. Stands purely of second-growth are rarely extensive. Much of the second-growth consists of sprouts from cut stumps and is of less promise than if of seedling origin.

DAMAGE BY FIRE. Much damage has been done by fire which, in the Southern Appalachian region, is usually ground fire carried by the dead leaves and humus layer of the forest floor. These fires destroy softwood seedlings outright, kill small hardwood seedlings and sprouts back to the ground, and cause wounds in larger saplings and trees, paving the way for decay which progresses inside the stem as the tree

grows. Burned stands thus contain many crippled trees; though thrifty in appearance they may contain little or no promise, becoming more of a liability than if the stand had been completely killed by the fire.

THE CHESTNUT BLIGHT. This disease has already practically exterminated the chestnut in the forests of southern New England, New York, Pennsylvania, New Jersey and Maryland, and is actively continuing throughout the southern mountains, where chestnut has been the most abundant timber species. After the costly and ineffective efforts to stamp out the blight farther north, and in view of the fact that the blight is now present and deeply entrenched practically everywhere in the Southern Appalachians, further expenditures aimed to stop this blight appear unjustifiable. Conditions set up during the death of the chestnut, however, present important problems connected with the succeeding stand.

INSECT ENEMIES. Aside from the chestnut blight the forests of the region are apparently free, at present, from any single serious disease, but there are several insect pests which are important. The most dangerous of these, because of the importance of shortleaf and other yellow pines in the region, is the southern pine beetle, *DENDROCTONUS FRONTALIS*. The hickory bark beetle *ECCOPTOGASTER QUADRISPMOSUS* has been responsible for the death of many hickory trees during the past three years. Serious damage is done to black locust by the locust borer, *CYLLENE ROBINTAE*. Insects cause a heavy loss of seed of many species, particularly the oaks. Investigations leading to control measures for these and other injurious insects are therefore of the greatest importance.

BIOLOGICAL PROBLEMS. Game and wild life are an important element in the forest. Deer, bear, turkeys, grouse, and quail are still locally abundant at places in the mountains and the Coastal Plain. The natural environment, however, is subject to radical changes as the result of forest fires, logging, and the increase of travel to the woods. This reacts, in turn, upon the abundance of game. To restore the natural balance and thus maintain or increase the game population special efforts will be necessary, based upon a knowledge of the relation of the animals to forest conditions. Too many animals, however, may do serious damage on reproducing areas. Deer, for example, will browse on the reproduction of oaks, yellow poplar and other valuable tree species. Chipmunks, mice, and other rodents, destroy large quantities of tree seeds and may perhaps be the chief causes of the failure of desirable species in the reproduction. These facts stress the need of more knowledge of the habits of forest animals as a part of the general basis for forest management.

STREAM-FLOW AND EROSION. The Southern Appalachian Mountains contain the watersheds of streams that flow eastward to the Atlantic and westward, by way of the Mississippi and Ohio Rivers, into the Gulf of Mexico. The waterpower available from these streams has been estimated at more than 3,000,000 horsepower. To develop this power costly reservoirs have been and will be established. The silting up of these reservoirs by soil eroded from the watersheds above them is a serious problem, affecting the cost of maintenance and length of life of the reservoir. The filling of stream channels by eroded material is also serious. It is believed that the maintenance of a forest cover and of good forest soil conditions on the watersheds will not only reduce the loss from erosion and silting to very small proportions, but will also tend to reduce the irregularity of the flow of streams and moderate the severity

of floods. The only way to find out whether or not this is the case will be to make comparative studies of watersheds in thrifty, natural condition, and as left by logging and fire.

THE ROLE OF FOREST INVESTIGATIONS. The processes and agencies at work in the forest may be classed as destructive and constructive. The destructive agencies include, among others, those discussed above - fire, disease, insects, excessive numbers of woods animals, and erosion. The constructive processes fall mostly under the headings of reproduction and growth. The purpose of forest investigations is to supply fundamental information upon both the destructive and constructive elements, for use in timberland management.

The outstanding objectives of timberland management are: (1) to prevent forest fires; (2) to convert commercial logging, which is generally unconcerned with forest replacement, into a treatment which combines forest utilization with forest reproduction, providing for an equally good or better forest when the old is removed; and (3) to convert large areas of timberland mostly cut-over and largely burned-over, from a low to a high state of productivity, considering productivity in its widest meaning, with references to stream protection, game management, and timber growing.

The work of the Station so far has fallen under the following heads:

MANAGEMENT. Studies to determine best methods of cutting mature hardwood stands and of thinning young ones; survey of the condition of natural hardwood reproduction, following different methods of cutting; replacement of blight-killed chestnut by other species; growth and natural reproduction of loblolly pine; methods of management necessary to (1) keep the forest in a generally productive condition and (2) stimulate production to the full capacity of the soil; study of the reproduction after cutting and fire in the spruce type.

PROTECTION (INCLUDING STUDIES OF RESULTS OF DAMAGE FROM VARIOUS CAUSES). Study of damage to trees from forest fires and of the factors which affect the severity of the damage; determination of a method of forecasting forest fire weather; studies of the life history of the southern pine beetle; studies on turpentine borer *BUPRESTIS APRICANS*; further studies on locust borer *CYLLENE ROBINIAE*.

FORESTATION tests of various coniferous species planted on cut-over areas in the high spruce forest and of hardwood and coniferous species at lower altitudes; study of the Biltmore plantations and of other plantations.

TREE STUDIES. studies of the characteristics and requirements of various species, including chiefly the rate of growth, volume, reproductive efficiency, and methods of management based upon these characteristics. Completed for yellow poplar and southern white cedar; under way for oaks (work transferred to the Central States Forest Experiment Station).

MENSURATION. Establishment of permanent sample plots in young stands for the determination of the rate of growth.

The status of these lines of investigation and the plans for continuance will be discussed under a later heading.

## Organization and Development

### Funds and personnel

During its first five years the Station's annual allotments were between \$17,000 and \$21,000, which provided a permanent staff of four technical men and a clerk, with a small amount of temporary assistance. It became apparent that these allotments were totally inadequate for the large volume of work to be done, and in 1926 an increase of \$18,000 was made available by Congress. This brought the allotments of July 1, 1926 and 1927, to \$37,450. Four more technical men and another clerk have since been added to the permanent staff, in addition to specialists in forest entomology and pathology, who are financed by the Bureaus of Entomology and Plant Industry.

While the doubling of the Station's resources has greatly increased its capacities, much of this increase has been absorbed in a relatively few of the larger projects already under way, which had not previously received the consideration their importance warranted. Only one new project of any magnitude, the loblolly pine study, has been initiated. In connection with the continuing projects, however, the larger amount of temporary assistance made possible by the increased funds is especially gratifying. This has not only stimulated field work, but it has greatly expedited office compilation of the data, a task which the smaller force had previously found difficult.

During the last few months the field presented for forest investigations in the Southern Appalachian region has been somewhat tentatively reviewed and a schedule of needed work prepared. This preliminary outline contains enough important projects to require the continuous service for many years of a much larger staff of specialists than the Station now has. The extent of territory and the wide extremes of forest conditions found in it make the task of supplying the data for management a very large and complicated one. With the present staff the Station can not hope to make rapid progress. A considerable increase in the force will be needed to furnish the volume and variety of fundamental information that will be needed for forest management.

The staff was reduced last July by the transfer of E. F. McCarthy to become Director of the Central States Forest Experiment Station, but the appointment of Junior Forester Arland L. MacKinney leaves the staff of the same size as last year. Assistant Silviculturist F. W. Haasis, who left the Station in the fall of 1926 on leave for post-graduate work at Johns Hopkins University, did not return until June. He left again in September to continue his advanced courses. Junior Forester I. H. Sims also left in September for advanced work at the University of Michigan School of Forestry and Conservation. The Station has thus been deprived of two of its permanent staff for a large part of the year. Further inroads upon its working capacity were occasioned by the drafting of two men, in the middle of the field season, to assist in the study of forest and flood relations in the Ohio River drainage area. One field assistant was released in exchange by the Central States Forest Experiment Station.

Mr. R. A. St. George, of the Division of Forest Insect Investigations, Bureau of Entomology, spent some time at the Station cooperating with J. A. Beal in forest insect investigations. L. H. Reineke, of the Branch of Research, Forest Service, was detailed to the Station for about two months for office and field work connected chiefly with forest measurements. His work will be discussed in the report on investigations.

### Appalachian Forest Research Council

The Council was organized in 1925 through the appointment by the Secretary of Agriculture of 24 men prominent in the lumber, pulp and paper, mining, railroad and other industries, State foresters and other State officers. The purpose of this organization is to enlist the interest and cooperation of the principal industries of the region in the development of forest research and forestry in general. It naturally forms an advisory board for the Station.

The result has exceeded all expectations. The Council has shown a deep and exceedingly helpful interest in the Station's work from the start. The individual members have contributed their time and the expense of travel to the meetings, and through resolutions and activities as individuals and committees have been very largely responsible for the development of the Station along new and important lines.

The Council has held four meetings: at Asheville, N. C., February, 1925; at Richmond, Va., January 1926; and at Asheville, August, 1926, and October, 1927. At each of the meetings reports on current research activities have been presented by the Experiment Station and its cooperators, including the State foresters of the region, and these have given rise to constructive discussion and suggestions. At its first meeting the Council passed a resolution urging the Department of Agriculture to assign a forest pathologist and a forest entomologist to conduct investigations in cooperation with the Appalachian Station. Each of these assignments was later made. The State forestry departments were urged to obtain as complete and reliable forest fire records as possible, and the United States Weather Bureau was requested to develop a fire weather prediction service and to cooperate with the Experiment Station in forest fire studies. On account of insufficient funds the Weather Bureau has not yet been able to do this.

Another resolution called attention to the need of a contact service between the experiment station, on the one hand, and the wood-working industries, the general public, and those directly concerned with the development or exploitation of timber-lands, on the other.

At the October, 1927, meeting seven subjects were discussed:

1. The role of forests and forest management in flood and erosion control.
2. Relation of forest management to game and wild life.
3. Next year's program for the Station: should increased emphasis be placed upon intensive investigations?
4. Investigations in forest entomology.
5. Forest pathological studies.
6. The situation as to logging and mill-scale studies.
7. Nation-wide movements in forest research.

A resolution was adopted recommending as new projects for the Station:

1. Studies of the growth of irregular and understocked stands.
2. Conditions limiting forest types.
3. Fire damage to forest soils.
4. Seed production and germination of important hardwoods.
5. Methods of eradicating underbrush prejudicial to reproduction.
6. Methods of slash disposal.

Other resolutions passed at the meeting advocated:

1. A logging and mill scale study.
2. The assignment to the Appalachian region of a specialist in wood utilization.
3. The assignment to the region of a specialist in biological studies.
4. That steps be taken by Congress toward the solution of the problem of the relation of forests to flood control and the silting of reservoirs.
5. The support of forest research in general by legislative action.
6. The need of a fully equipped and financed school of forestry in the South.

The resolution asking the assignment of a biological specialist for studies of game and other wild life has already been favorably considered by the United States Biological Survey, and a preliminary study has been arranged for the coming spring.

#### Branch Stations

The investigative procedure follows two general lines: extensive work over large areas to collect data representative of a great variety of conditions; and detailed, close observations of experiments, requiring repeated returns for measurement. The latter class could not be indiscriminately scattered through the region without danger of loss through changing ownership of the properties on which they are located, excessive cost of travel, and general confusion. For this reason a policy of concentrating these experiments at a very few fully representative localities has been designated. These localities, to be known as branch stations, or working centers, are to be carefully selected with a view to permanency of operation, reasonable protection against loss of experiments, accessibility, and favorable living and working conditions. A very important requirement is that the conditions at a branch station shall be fully representative of an extensive area, as to forest types and sites, age classes, past forest history, soil, geology, topography, climate, etc. An important feature is the presence of easily accessible forest tracts which can be developed as experimental forests. In addition to the function of these forests as sites for experiments, they will sooner or later be brought under sustained yield management.

In compliance with instructions received, a report was prepared during the past year designating the topographic, climatic, geological, and soils divisions of the region, and their relations to the forest vegetation. This report recommended the approval of four branch stations and suggested the establishment of others, in all important sub-regions, as rapidly as the need arose. Those specifically recom-

mended were at Bent Creek, in the Pisgah National Forest, near Asheville; Berea, Ky., on the lands of Berea College; Edinburg, Va., from which representative forest types in the Shenandoah National Forest are easily accessible; and Marlinton, W. Va., with access both to the high spruce and northern hardwood types in the Monongahela National Forest and to southern hardwoods in the Seneca and Watauga State Forests. Work by means of permanent sample plots is already under way at Bent Creek and nearby points, at Berea, and at Edinburg. BENT CREEK. Bent Creek closely adjoins the Biltmore Estate, on which thinning experiments, started in 1916, five years before the Appalachian Station was established, are under way. It is nine miles from Asheville, from which permanent experiments in the spruce type in the Black Mountains and in hardwoods on the Pisgah National Forest, near Brevard, are a half-days journey.

In 1925 an area of between one hundred and two hundred acres in Bent Creek Valley, Pisgah National Forest, was designated for purely experimental purposes. This area was increased in 1926 to one thousand acres to be used as an experimental and demonstration forest. A formal agreement as to the administration of the tract was prepared in 1927, and a topographic and type map was prepared following a survey and timber cruise of the area.

The Bent Creek forest is very much understocked with thrifty, actively growing timber of desirable species. Practically all the large trees are defective, and occupy much growing space which should be filled with sound young trees. Of the smaller timber a large part is of inferior species, such as red maple, sourwood, scarlet oak, black gum, and some chestnut below the sizes taken out in the current sales of poles and extract wood. If the tract were to be placed under commercial instead of experimental management, the general treatment which would be most desirable would be an improvement cutting over the whole area. In many places this would amount to clear cutting with seed trees. Since the area is to be used solely for experimental purposes, many different kinds of treatment will be tried.

The extensive use which will be made of this area for experiments in silviculture, forest entomology, pathology, and presumably biology makes it imperative that a very careful and detailed plan of management be prepared. This is to be done in 1928, at the first opportunity.

In 1925 a field laboratory and garage were erected at Bent Creek. This laboratory is used as quarters for field parties as well as for laboratory purposes, and meetings of the Appalachian Forest Research Council and the Southern Appalachian Section of the Society of American Foresters have been held there. A water system for experimental purposes has been completed during the past year, as well as an insectary and other improvements. The experimental work on the area will be discussed under the subject of investigations.

BEREA. An excellent opportunity for experiments in the hardwoods of eastern Kentucky is presented on the Berea College Forest. Aside from experiments started in 1923 and a few later, no definite development has yet been undertaken. It is believed that specific arrangements should be made with the College authorities during the present year, and that necessary improvements should be provided. In connection with the Berea work, field parties will visit the Robinson sub-station, at Quicksand, Ky., of the Kentucky Agricultural Experiment Station, for survey purposes and to consider this tract as a location for permanent sample plots.

EDINBURG, VA. Plots established in 1924 were remeasured and new plots established in 1927. No improvement work has been done.

MARLINTON, W. VA. No work of any kind has yet been done at Marlinton, pending its approval as a branch station.

NATURAL AREAS. Areas of virgin timber are difficult to find in the Appalachian region at locations and under conditions which would justify their use for permanent study. With the possible exception of the Watauga State Forest, in West Virginia, none of the proposed branch stations has any virgin timber whatsoever. The advantage of natural areas of virgin timber as standards from which to judge silvicultural practices and study natural processes is very great. It is therefore important that any such stand which is found on National Forest, National Park, or other land of stable ownership should be carefully considered as a possible scene of operations for the experiment station. Efforts to find suitably located virgin stands will therefore be made by the Station during 1928.

The Robinson Sub-Station of the Kentucky Agricultural Experiment Station to be considered as a working center

The Appalachian Station has considered undertaking work on the Robinson tract near Quicksand, Ky., and it is planned to make an examination of the tract with this end in view during the coming spring.

Cooperation

Most of the work done by the Station is cooperative. The Station has maintained helpful contacts with timberland owners in the region, with State foresters, National Forest Supervisors, lumber and pulp companies, colleges and forest schools, and State and regional forestry associations. As has already been shown the Appalachian Forest Research Council has been the means of providing many valuable contacts.

Particular mention should be made of the cooperation with Berea College; with the State foresters of Virginia, Tennessee, and North Carolina; the Champion Fibre Company, of Canton, N. C., in the use of nursery seed-beds for experimental purposes; the Biltmore Estate in connection with the studies of plantations; the supervisors of the National Forests in the region; with the Georgia and Iowa State schools of forestry whose summer school students assisted in several projects; with the Yale School of Forestry in connection with the oak germination study; and with many industrial organizations, notably the Richmond Cedar Works, Camp Manufacturing Company, and the West Virginia Pulp and Paper Company. Such cooperation has materially aided the Station in its work.

For 1927 special acknowledgement should be made of the cooperation of timberland owners and operators and of individuals on the Coastal Plain for assistance given in the loblolly pine study.

Publications and addresses

An important part of investigative work is the publication of the results. The usually long duration of experiments in forestry commonly defers the publication

of final results, but reports of progress are often of much value. On general forestry, as well as on investigative subjects, the investigator's point-of-view may also be of service. The Station has accordingly made its work public as rapidly as possible, through addresses, published papers, and specially prepared and distributed mimeographed articles. During the past six and one-half years 50 addresses have been given by members of the staff, 82 reports and articles have been published, and 68 reports prepared which were not published.

Papers published or prepared in 1927 are listed by title and author at the end of this report. A mimeograph machine acquired during the year makes it possible to distribute more material than formerly to the Station's mailing list, which now numbers about 600. Among the articles mimeographed and distributed were several of a series of radio talks broadcast from Station WWNC, Asheville.

Members of the staff took part informally in various meetings during the year, notably those of the North Carolina Academy of Sciences; the Southern Appalachian Section of the Society of American Foresters, meeting at the Bent Creek field laboratory and at Nashville, Tenn.; the North Carolina Forest Fire Conference, at Black Mountain, N. C.; the Duke University summer school and various luncheon clubs in and near Asheville. Members of the staff also attended the meetings of the International Soils Congress, at Washington, and the American Association for the Advancement of Science, at Nashville, in addition to the organizations before which prepared addresses were given, as shown elsewhere.

#### Review of the Past Work of the Station

The amounts spent on the different lines of investigation indicate their relative importance. The following summary shows the distribution of the Station's allotments, "overhead"\*\* being prorated to activities:

Table 1. Distribution of expenditures for fiscal years 1922-1927.

Activity	1922	1923	1924	1925	1926	1927	Total yrs.	Per cent of total for all activities.
							1922-1927	
Management	\$9,257.00	\$5,066.00	\$6,676.00	\$5,993.00	\$8,160.00	\$13,698.00	\$48,850.00	37
Protection- (fire, grazing)	2,713.00	4,737.00	2,423.00	4,408.00	4,115.00	2,637.00	21,033.00	16
Tree studies	2,356.00	4,177.00	5,677.00	5,390.00	4,696.00	10,091.00	32,387.00	25
Forestation	1,812.00	2,564.00	2,506.00	1,805.00	2,020.00	2,952.00	13,659.00	10
Mensuration	—	—	—	—	—	436.00	436.00	(1) 0
Investigations general	1,719.38	788.22	1,106.93	2,424.00	1,669.57	7,351.72	15,059.82	12
Total -	17,857.38	17,332.22	18,388.93	20,020.00	20,660.57	37,165.72	131,424.82	100

(1) Less than 1 per cent.

\*\*Overhead" consists of clerical salaries, rental of quarters, cost of buildings (materials and labor) and improvements, purchases of motor trucks, equipment, and office furniture, routine administration, and all other expenditures not assignable to investigative subjects. It has amounted to from 35 to 44 per cent, averaging 41 per cent of the total annual appropriation.

## MANAGEMENT

The first studies in forest management undertaken by the Station in 1921 were (1) silvicultural and protective requirements (measures necessary to keep forest land reasonably productive and to produce full forest crops); (2) progress of natural reproduction after different methods of cutting in hardwood forest; (3) natural reproduction on cut-over spruce-fir lands; and (4) effects of thinning in plantations on the Biltmore Estate. In 1924 two other studies were begun; (5) the natural replacement of blight-killed chestnut, and (6) growth as affected by thinning in second growth stands in the mountains. In 1925 there were added (7) thinnings in loblolly pine, and (8) a study of the germination and early survival of oaks; in 1926 (9) the management of the Bent Creek tract as an experimental demonstration forest; and in 1927 (10) a study of the reproduction, growth, and management of loblolly pine.

### Silvicultural and protective requirements

In 1921 the Forest Service began studies in all the forest regions of the country to formulate the measures necessary to keep forest lands productive and to grow full timber crops. The Southern Appalachian Mountains and Piedmont Plateau regions were assigned to the Appalachian Station. The complex forest composition and variety of conditions left by logging and fire made the analysis of the situation a difficult matter, and while two or three reports were prepared, none has been satisfactory due largely to the lack of illustrative material. Enough of the results of various projects have now been compiled to furnish this material and what is hoped will be a finally satisfactory report will be prepared early in 1928, to be published as "Timber Growing and Logging Practice in the Southern Appalachian Region." This project has been conducted by E. H. Frothingham and E. F. McCarthy. Preliminary results have been published in trade journals and otherwise.

### Methods of cutting and natural reproduction in the hardwood types

The main purpose of this study is to furnish the basic data for a progressive development of silvicultural methods in the Southern Appalachian hardwoods. It is thus a continuing project, with no definite date assigned for completion but with progress reports whenever results of special value become available.

The study covers a broad field and three phases are recognized, consisting of (1) extensive surveys of cut-over areas, the past history of which is more or less well known, the purpose being to determine in a general way the kinds and amounts of reproduction following different degrees of cutting, in different forest types; (2) establishment of permanent sample plots cut-over in a definite manner and periodically observed to determine the progress and growth rate of the reproduction; and (3) intensive studies to find the factors responsible for the success or failure of reproduction. The last named phase opens the way for separate projects, such as that of the germination and early survival of the oaks.

The work has been under the direction of E. H. Frothingham, but all members of the staff have taken part in it, particularly F. W. Haasis and, in 1927, J. H. Buell, C. F. Korstian, and I. H. Sims.

IN 1922 two fenced sample plots of a quarter acre each were established on cut-over hardwood land on tributaries of Curtis Creek, Pisgah National Forest. The progress and growth of the reproduction on these plots is being periodically measured.

In the same year, about 50 acres of strip survey, representative of about 1,000 acres of cut-over land, were run in West Virginia and at two points in North Carolina. One of these areas, on Curtis Creek, was reexamined in 1926 and the results, which are of considerable interest from the standpoint of tree reproduction, are shown in the following tables:

Table 2. Composition of moist site as compared with dry site forest on an area last cut over in 1919. Horse Fork, Curtis Creek, Pisgah National Forest.

SPECIES	Number of trees per acre 7 inches and larger d.b.h.					
	Original Forest		Trees removed 1919		Trees standing 1919	
	Lower slope.	Ridge	Lower slope	Ridge	Lower slope	Ridge
Chestnut	36	21	32	17	4	4
Chestnut oak	2	27	1	24	1	3
Other oaks and hickory	8	6	2	--	6	6
Red maple	4	7	2	1	2	6
Yellow poplar	7	4	1	--	6	4
Black gum	1	3	--	1	1	2
Hemlock	3	--	2	--	1	--
Miscellaneous	6	1	--	--	6	1
Total	67	69	40	43	27	26

Table 3. Reproduction in 1926 seven years after the last cutting (1919), in stand shown in Table 2.

SPECIES	Number per acre		Percent	
	0-6 in., d.b.h. Lower slope	Ridge	Lower slope	Ridge
Yellow poplar	164	12	24	2
Chestnut	98	344	15	42
Red maple	61	103	9	13
Hickory	47	7	7	1
Black locust	25	35	4	4
Chestnut oak	22	102	3	12
Other oaks	13	27	2	3
Hemlock	20	--	3	--
Black gum	8	11	1	1
Other timber species	8	--	1	--
Small tree species	211	178	31	22
Total	677	819	100	100

Per cent of sprout origin 28 32  
(In 3-6 inch diameter class)

The dry ridge site has the largest stand of reproduction and a greater proportion of it is of timber species. The composition, however, is much inferior to that of the moist lower slope. Since the chestnut is already infected with blight the chestnut can be written off as a loss. In fact, the fast growing chestnut sprouts are a serious impediment to the establishment of desirable species. On the moist site almost a quarter of the reproduction is of yellow poplar, the most desirable species of all, according to present standards. As the chestnut dies its place will be taken by other species, but in what proportions remains for future examinations to determine.

IN 1923 four permanent sample plots were established at Berea, Ky., in the hardwoods which had been cut over some 30 years previously. Two were selectively cut in 1923 according to a prearranged plan and two were left intact as controls. Series of small interior plots were laid out within the larger plots in 1924 for the periodic observation of the reproduction.

One of the Berea plots presents an example of the unusual speed of reproduction where conditions are favorable. Two-thirds of the trees on the plot were removed in 1923. The results of two counts of the reproduction, in 1924 and 1926, were as follows:

Table 4. Reproduction following controlled cutting in sample Plot 1, Berea, Kentucky.

Reproduction per acre	1924	1926	
	Number	Number	Per cent
Total	3,254	15,643	100
Timber species	2,769	11,749	75
Dogwood, sassafras, redbud, etc.	485	3,894	25
Timber species, seedling	2,409	9,153	59
Timber species sprout	360	2,596	17
Timber species over 4 feet high	175	3,346	21

In 1926 sugar maple formed 26 per cent, ash 23 per cent, and yellow poplar 10 per cent of the reproduction, as compared with 45.2 and .5 per cent respectively, of the original stand over  $3\frac{1}{2}$  inches in diameter, breast high. This increase in the cases of poplar and ash are very gratifying. The extremely rapid height growth of the reproduction is no less encouraging. In 1924 there were 64 advance growth seedlings per acre which were over seven feet high, while in 1926 there were 815 seedlings and sprouts in this class, many of them 9 feet high and some of them already 1 or 2 inches in diameter breast high.

Four half-acre plots were established, in 1923, in a six-year old burn at the base of Lookingglass Rock, Pisgah National Forest. The purpose of this experiment was to determine the effectiveness of light and heavy cuttings to save an abundant stand of yellow poplar seedlings from being choked out by less desirable species. Two of the plots were treated and two left as controls. Interior reproduction plots were laid out within the larger plots. An average of 739 chestnut, 665 silverbell, and 369 sumac per acre were removed from the treated plots.

A very satisfactory increase in height of the liberated yellow poplar was noted in 1927. In the control plots there was little or no growth while in the treated plots there had been an increase in average height of 56 per cent over the average height at time of liberation. In the lightly cut plot, in which only the poplar and silverbell were removed, the poplar is coming up through the locust, walnut, and sumac, where these species occur. The larger poplar reproduction one inch and over in breast high diameter is coming into the upper crown cover in excellent shape. The chestnut sprouts on the area are badly blighted and it is not likely that any further cutting of chestnut will be necessary.

IN 1924 two pairs of permanent sample plots were established on North Mountain, Shenandoah National Forest, near Edinburg, Va. Of each pair, one  $\frac{1}{2}$  acre plot was marked and later cut over with reference to the best utilization of chestnut and of the poorer or less well located trees of other species; the other plots were left intact for future comparison as to reproduction and growth.

IN 1925 two sample plots were established at Bent Creek to determine the capacity of yellow poplar seed to withstand ground fires and restock burned areas. One of the plots was on freshly burned, the other on unburned land adjacent. Both were cleared of trees, and small interior plots were laid out on them. Though there were no young seedlings present in May, when the plots were established, a count made in June showed freshly germinated yellow poplar seedlings at the rate of 36,000 per acre on the burned plot and 2,400 on the unburned. It was observed in 1927 that many of these seedlings had disappeared, but whether because of frost, competition, the severe drought of 1925, or browsing by deer or rabbits was not determined.

IN 1926 no new work was started.

IN 1927 it was planned to devote practically the entire energies of the Station to this study, with three field parties assigned to an extensive survey of cut-over areas and a fourth to the establishment of permanent sample plots. Several things interfered with this plan, and it was possible to operate only one field party, full time for  $2\frac{1}{2}$  months, on the extensive survey, establish three permanent plots, and reexamine the reproduction in the plots started on North Mountain, Shenandoah National Forest, in 1924. Two of the plots established in 1927 are on North Mountain, the third at Bent Creek. A series of plots put in at Bent Creek last summer in the study of chestnut replacement will contribute also to the study of reproduction after cutting.

The extensive survey party, led by J. H. Buell, examined 13 cut-over areas, unburned since cutting, aggregating some 2,500 acres, in the Unaka, Natural Bridge, and Shenandoah National Forests. This survey was by means of sample areas (not permanent plots) representing the various forest types, and ages and conditions of cutting met with; 227 of these were of  $\frac{1}{2}$  acre (1 x 5 chains), while 50 were from .1 to .4 of an acre in size. On these areas all the trees above 3.5 inches in diameter were tallied as well as all stumps. This furnished information upon the original stand and the degree of cutting. Within each half-acre plot the small trees from 0.5 to 3.5 inches inclusive, in diameter, breast high, were tallied on strips of one-twentieth of an acre. This gave an idea of the composition, density and origin, whether from seed or sprout, of the larger reproduction and advance growth. On a

still smaller area of one five-hundredth of an acre the small reproduction between 0.5 feet high and 0.5 inches in diameter, breast high, inclusive, was recorded. Separate record was kept of seedlings and sprouts, of the number of sprouts per stump, of the reproduction which was free from shade, and of the amount and condition of slash, recorded by milacres.

The data from this survey were transferred to punch cards, verified, and sent to Washington for sorting and tabulating by special equipment. A preliminary tabulation which was made for a moist and a dry site hardwood type is of interest in showing the remarkable reproduction quality of the unburned hardwood forest, especially in seedlings. If the areas had been burned the proportion of sprouts would have been much greater.

Table 5 brings out the relation of desirable to undesirable species in the reproduction, illustrating the need of cultural studies in the development of valuable stands. It also indicates an important cause of loss of reproduction occasioned by large trees which spread out over it. Although there are over 1200 seedlings per acre of desirable species in each case which are now free to light, this number will rapidly be reduced by competition as well as by the increasing overhead shade of the larger trees. Of the larger trees (3.6 inches and over, breast high) on the moist site, only 25 out of 111 per acre were promising trees of good species; on the dry site, 27, out of 103, were of promise. This illustration indicates the kind and importance of the information which the data from this study will yield when completed and analyzed.

One phase of the 1927 survey was a study of the height growth of seedlings and sprouts of the various species on the cut-over areas examined. The field party made a great many cross-section counts of the rings of annual growth at given points on the stems of dominant seedlings and sprouts from which the progress of height growth under different site conditions can be determined for all the competing species. This should be an important adjunct of the quantitative survey of the reproduction and is expected to assist the interpretation of the process of competition in the regeneration of cut-over areas. The data obtained in this phase of the study were taken to Ann Arbor by I. H. Sims to be worked up and analyzed by him as a thesis.

The third step in the investigation of the natural reproduction of hardwoods - intensive studies of the causes of reproductive phenomena - was entered in 1925 with a study of the germination and early survival of oaks. This was made an independent investigation and will be discussed later.

#### Natural reproduction on cut-over spruce-fir lands

An extensive survey of spruce reproduction was conducted in 1922 and 1923 by field parties directed by C. F. Korstian. The reproduction was counted on sample strips 10 and 20 feet wide across the cut-over areas. The actual area of the strips tallied in the two years was 47.1 acres. The areas studied were in the high altitude spruce-fir type of West Virginia, Tennessee, and North Carolina.

Table 5. Tree reproduction 7 years after cutting 1/ on areas unburned since cutting; seedlings 2/ and sprouts 0.6 foot high to 3.0 inches in diameter, breast high, inclusive. Unaka National Forest, Tennessee.

Species	Moist Site			Dry Site		
	Total	Free from shade		Total	Free from shade	
		Seedlings	Sprouts		Seedlings	Sprouts
<u>Most desirable</u>						
Yellow poplar	153	111	---	---	---	---
Oaks, red and chestnut	1469	317	26	3325	188	---
Oaks, white and black	---	---	---	2175	600	---
Hickory	498	145	2	862	425	---
Sweet birch	955	585	---	---	---	---
Black locust	153	30	4	138	---	---
Basswood	217	87	38	---	---	---
Cucumber, white ash	47	23	---	---	---	---
White pine	---	---	---	25	---	---
Total	3492	1298	70	6525	1213	---
<u>Less desirable</u>						
Chestnut	1639	217	298	462	25	12
Scarlet oak	---	---	---	75	38	---
Red maple	262	45	---	3200	1325	---
Black gum	132	---	21	1138	12	---
Sourwood	302	34	6	62	50	---
Dogwood	539	94	---	287	125	12
Others	891	211	---	2388	500	---
Total	3765	601	325	7612	2075	24
Grand total	7257	1899	395	14137	3288	24

1/ Seventy and two-tenths per cent of total basal area removed on moist site and 72.5 per cent on the dry site.

2/ Seedling sprouts included with seedlings.

The following table furnishes an illustration of the type of data obtained in this survey. They bring out the differences in reproductive conditions between burned and unburned cut-over lands:

Table 6. Reproduction, less than 1 inch in diameter breast high, on burned and unburned cut-over areas in the spruce-fir forest. Jackson and Haywood Counties, N. C.

Species	Unburned	Burned 1918 (Fall)
	Cut 1918-19 Examined 1922.	Cut 1917 Examined 1922
	No. per acre.	No. per acre.
Red spruce	88	16
Southern balsam fir	558	7
Hemlock	27	1
Yellow birch	715	4917
Small tree species and tall shrubs.	5418*	23789**
Total	6803	28730

\*Rhododendron 12 per cent, fire cherry 69 per cent.

\*\*Rhododendron 10 per cent, fire cherry 75 per cent.

In this survey borings were made in the trunks of trees left isolated by cutting, to study the rate of acceleration in diameter growth due to the removal of the surrounding timber. Seedlings were analyzed to determine their growth rate. The growth of spruce seedlings was found to be disappointingly slow. Only on thin soils, as on ridge tops, was the spruce in the lead. On the better soils the odds were generally against the spruce due to the heavy reproduction of hardwoods. A single fire usually results in pure hardwoods, which are decidedly inferior at these high altitudes.

Heavy demands upon the time of the staff prevented the working up of the field data for the spruce type study until 1927. The data have now been compiled and the final report upon the study will be prepared by Korstian for publication early in 1928.

#### Effects of thinning in plantations on the Biltmore Estate

The forest plantations at Biltmore, N. C., which will be discussed under the heading of Forestation, offer good opportunities to determine the value to be derived from thinning. Four sets of permanent sample plots (nine plots in all) were established in 1916 by E. H. Frothingham, Supervisor Verne Rhoades of the Pisgah National Forest, and Professor L. J. Young, of the University of Michigan. Two sets of plots are in pure white pine plantations, one in mixed shortleaf and white pine, and one in sugar maple with a few scattered white pines. One of each set was thinned in 1916, the other left intact as control. The plantations were from 16 to 18 years old in 1916. Each tree was given a number and its size and crown class were recorded.

The station fell heir to these plots in 1921, and a second thinning was made in 1923. Summarized results of the thinning in one set of plots are given in the following table:

Table 7. Summary of results of thinnings in white pine sample plots, Old Orchard plantation, Biltmore Estate, Biltmore, N. C. Planted in March, 1899.

Year	Stand	Average diameter breast high	Number of trees per acre.	Volume per acre.
		<u>Inches</u>	<u>Cubic feet.</u>	
<u>Thinned plot (1 a)</u>				
1916	Before thinning	3.3	2,304	2,710
	Trees cut	2.6	1,168	736
	Trees left	4.0	1,136	1,975
1923	Before thinning	4.6	1,056	2,666
	Trees cut: dead	---	80	50
	Trees cut: living	4.0	544	905
	Trees cut: total	---	624	955
	Trees left	5.4	512	1,762
<u>Unthinned plots (1 b,c)</u>				
1916	Living	3.1	2,580	2,706
1923	Living	3.8	1,908	3,178

By the thinning of 1923 the volume per acre of the thinned stand was reduced by 1416 cubic feet below that of the unthinned controls. The thinning, however, removed the poorer and smaller trees which were rapidly falling behind and must soon have died. It was designed to increase the growth of the better trees by removing those which were crowding them, and this is indicated by the increase of average diameter, breast high, immediately after thinning as compared with that immediately before. The total volume per acre removed in the two thinnings was 1691 cubic feet. This was utilizable and represents a clear gain over the unthinned controls in which this material rapidly dies and decays. The net gain from the thinnings is the volume removed (1691 cubic feet per acre) less the difference in volume (1416 cubic feet) of the trees left standing after the second thinning in the thinned, as compared with the unthinned plots. This amounts to 275 cubic feet, representing a yield for the thinned plot 8.7 per cent heavier than for the unthinned.

The plantations are unfortunately in too small blocks to permit effective experiments in different methods of thinning.

Preliminary results of the thinnings were distributed in mimeographed form as a part of the results of the general study of the Biltmore plantations, to be discussed under Forestation. The thinnings were under the general direction of Frothingham, but all members of the staff participated in the markings and measurements. Labor for carrying out the thinnings was obligingly furnished by the Biltmore Estate, which utilized much of the material removed.

#### Natural replacement of blight-killed chestnut

The chestnut blight started in the northeastern States and has steadily worked southward. In order to forecast its effects in the South and to determine, if possible, what steps can be taken to minimize the damage to the forest a study of the forest reproduction following the death of the chestnut in the Northeast was undertaken in 1924 by the Station in cooperation with the Northeastern Forest Experiment Station, State foresters, and the Yale School of Forestry. The work, for the Station, was under the direction of C. F. Korstian. Thinned and unthinned sample plots established in Connecticut from 1904 to 1910, for which full records were available, furnished an excellent field for study since the establishment of these plots antedated the appearance of the blight. Numerous small temporary plots were also tallied in the States in which the study was conducted.

The detailed results of the study in the Northeast were published in 1927 in the Journal of Agricultural Research and a shorter account was issued as U. S. Department of Agriculture Circular Number 100. Both papers were by C. F. Korstian, of the Appalachian, and P. W. Stickel, of the Northeastern Forest Experiment Station.

In 1926, preceding the removal of the chestnut timber from the 1,000 acre experimental tract at Bent Creek, in two sales made prior to the transfer of the tract to the Station, all individual chestnuts and clumps of sprouts of salable size were measured and the stumps marked with numbered tags in conformity with the records kept. This affords a record of value in the chestnut replacement study as well as in the general management of the tract for other experimental purposes.

In 1927 three permanent plots were established at Bent Creek and subjected to a heavy cutting in addition to the chestnut salvage cutting then in progress. Only well shaped trees of desirable species were left standing, as seed trees. Two plots were laid out on areas where only chestnut had been removed and two intact control plots were established. Horizontal crown projection maps were made for all plots. The records of trees, stumps and reproduction made on these plots conform to those commonly taken on permanent sample plots in the study of natural reproduction after cutting, to which these plots will materially contribute. Milacre plots (6.6 feet square) were established inside the larger plots as a means of observing the progress of reproduction.

In addition to the larger plots, 40 square rod plots were established around chestnut stumps to determine not only the rate and kind of replacement of the chestnut, but also the extent to which the repeated sprouting of the chestnut will retard replacement. Ten of the square rod plots were treated by each of the following methods:

1. All sprouts removed except the largest one.
2. Stump peeled to prevent sprouting.
3. Stump treated with sodium arsenite to prevent sprouting.
4. All sprouts left intact as controls.

One permanent plot in the chestnut replacement study was established in 1927 on North Mountain, Shenandoah National Forest, and plots near Mons, Va., established some years ago by members of the Office of Forest Pathology, Bureau of Plant Industry, were visited. This locality, in which chestnut originally made up 60 to 90 per cent of the stand, is quite representative of areas running heavily to chestnut and should be considered for the establishment of additional chestnut replacement plots, though not near any branch station.

Special attention to this problem of chestnut replacement is desirable because of the fact that in the mountains chestnut is the most abundant and one of the most widely distributed species, and its threatened extermination will make a very radical change in the character of several of the important forest types of the mountain region.

The study is being conducted by Dr. Korstian. Field work in 1927 was done by a field party led by Arland L. MacKinney.

#### Methods of thinning in mountain second-growth

As a new project for 1924, a study of thinnings in second-growth stands in the mountains was approved. Only two sets of plots have been established, one in mixed hardwoods on North Mountain, Shenandoah National Forest, and one in yellow poplar at Kagle Mountain, near the Bent Creek experimental forest. The latter has not yet been completed.

This study is expected to take advantage, for thinning purposes, of promising opportunities brought to light at branch stations in other investigations, such as the tree studies. It will provide for the collection of data on quality growth acceleration, the relative advantages of different kinds and degrees of thinning, salvage of subordinate crown classes, and the like. It is assigned to E. H. Frothingham and F. W. Haasis.

### Methods of thinning in loblolly pine

This study was approved in 1924. No new plots have been established, but in 1926 the fifth five-year measurement was made of such of the permanent sample plots as remained serviceable out of about 72 established in Maryland in 1906 by G. H. Myers and W. D. Sterrett. All but 13 of these plots were in loblolly pine on the Eastern Shore. The stands were even-aged and mostly young when established - from 3 to 18 years old, though a few were 40 years old at that time.

Three pairs of plots in shortleaf and loblolly pines started by W. D. Sterrett and W. R. Mattoon in 1911-13 in the Thomas Nelson Page Estate at Beaver Dam, Hanover County, Va., were remeasured in 1925.

In 1927 the Station cooperated with the Lee National Forest in the establishment of two thinning plots and one check plot in a 13-year-old stand of loblolly pine.

The Maryland plots now fall to the Allegheny Forest Experiment Station for further treatment in cooperation with the Maryland State Board of Forestry.

### Germination and early survival of oaks

The choice of the methods of cutting most likely to result in satisfactory reproduction depends largely upon the seeding efficiency of the different species of trees. The most abundant species in the hardwood forest are the oaks, as a group. A study of the germination and early survival of oaks was accordingly begun in 1924 as a part of the study of hardwood reproduction after different methods of cutting. Acorns of the important species of oak were collected by C. F. Korstian, assorted according to size, and planted at different depths in the Champion Fibre Company's nursery at Canton, N. C. Counts and measurements of the resulting seedlings made at intervals during the spring and summer of 1925 threw considerable light upon the relation of size of acorn and depth of planting to germination and early growth. Information was also obtained in the field as to the destruction of acorns by rodents and from other causes. Field storage methods were tried out, as well as experiments designed to find out how acorns of the white oak group, which in nature germinate in the fall, can be carried over until spring.

It was evident that a great deal of this investigation could not be satisfactorily conducted outside of a laboratory and greenhouse, neither of which was available at the Station. A cooperative arrangement was therefore made with Yale University under which Korstian carried the work to New Haven for the school year of 1925-6. Germination was there studied under controlled laboratory conditions, and a report upon the various factors affecting it was published as a doctorate thesis.

This project has thus been completed, but there are still important problems of seed production, distribution, and germination, that must be solved for the oaks as well as for other species. Further work is recommended under "Plans for 1928".

## Bent Creek Experimental Forest

The 1,000 acre tract at Bent Creek will be managed for experimental purposes only. It was turned over to the Station in 1926, and a boundary survey and stock estimate were made in that year. In 1927 a map was prepared showing topography, forest types, boundary and base line control, streams, roads, and trails. A management plan for the tract is urgently needed. This plan will serve as a guide to the location of sample plots, which should be placed with reference to a scheme of orderly development based upon the distribution and condition of the forest types.

Improvements so far made have already been referred to under Branch Stations.

## Loblolly pine study

A study of the reproduction, growth, and management of loblolly pine was started in 1927 under the direction of C. F. Korstian. Field work was begun in the spring by Korstian, F. H. Eyre of the Washington Office, and C. R. Hursh, and was continued in the autumn by a party of temporary assistants directed by Junior Forester A. L. MacKinney. The work followed two major lines (1) extensive surveys of cut-over and burned loblolly pine lands to determine the kind and amount of reproduction coming in on such lands, and (2) the growth of trees left after cutting. The reproduction was tallied for strips 1/10 chain wide and trees 4 inches in diameter and larger were recorded for strips one chain wide. In this work about 9 acres of reproduction and 89 acres of seed trees were tallied. The surveys were about evenly distributed between Virginia and North Carolina.

The data obtained on these strips are now being compiled. A few general conclusions were outstanding at the time of the field work.

Forest fires of ordinary intensity will generally destroy loblolly pine reproduction two or three inches or less in diameter, and unusually severe fires may kill trees as large as 14 inches in diameter which might otherwise have served as seed trees. Repeated fires prevent the establishment of pine reproduction on cut-over lands and, on the better loamy soils, favor an increase in hardwoods at the expense of the pine.

Pine reproduction is generally adequate, after a seed-crop, on cut-over loblolly pine lands unburned since cutting and bearing two or more seed trees per acre.

The kind, amount, and growth rate of the reproduction are influenced by the character of the soil. Soil, together with fire and heavy cuttings, may result in a complete change in the type of forest cover.

The study of the growth of loblolly pine trees left after cutting was concentrated on nine typical areas in Virginia and North Carolina. Detailed records of growth before and after cutting were taken by five year periods for about 1500 trees. A detailed description was made of each tree, including total height, height to base of crown, crown description, full notes on seed crop and other essential data. These data are being placed on punch cards for detailed analysis by means of the Washington Office tabulating machine. During the course of the field work the following points of interest were noted:

(1) The seeding capacity of the trees depends upon their dominance and crown development at the time of cutting; that is, the dominant and codominant trees bear more seed than the intermediate and overtopped trees.

(2) The promptness, after cutting, with which the trees left standing begin growth at an increased rate depends upon their dominance and vigor at the time of cutting and the extent to which they were released.

The distribution of growth along the bole before and after cutting is being studied by means of increment borings on standing trees taken at regular intervals from the ground to the base of the crown. Although the released trees showed marked acceleration in growth at the ground, very little increase was noted at the base of the crown. This is due to the fact that the growth rate at the base of crown was already rapid when the trees were released.

#### Disintegration of logging slash

Tree tops and branches which accumulate on the ground during logging introduce an element of danger from fire and may also interfere with reproduction. Whether this slash should be burned broadcast, piled and burned, piled and not burned, lopped and scattered so as to be close to the ground, or simply left in the woods as it fell, is a matter for careful investigation, since it will affect both the cost and the efficiency of silvicultural practice. Various methods of brush disposal may be indicated for different types and conditions of forest. Burning, as a general rule, is costly, dangerous, and a means of depriving the soil of elements of fertility. The risk of unburned slash will disappear as the slash disintegrates to a non-inflammable condition. The rate of disintegration depends upon the kind and size of the slash, the position in which it is left, the moistness of the site, and other factors. From the standpoint of fire menace, effect upon reproduction, and the relation of slash to soil conditions, a knowledge of the rate of disintegration of slash under different conditions is important.

A reconnaissance of this problem was made in October, 1926, by E. F. McCarthy of the Station staff, ranger C. L. Fink of the Pisgah National Forest, and Dr. George G. Hedgcock of the Bureau of Plant Industry. In a one week trip the party examined timber sale areas in the Pisgah National Forest, on which cutting had been done from 4 to 13 years previously. Some of the areas had been cut with and some without Forest Service supervision. In the latter case no disposition was made of the tops. The results of this survey, briefly summarized, are as follows:

Decay in the sapwood of the hardwood species observed begins in the first year of the cutting and is usually completed in four to six years. Inflammability of the slash in this stage depends on the degree to which it is exposed to drying. The shade of trees left in the logging, and of new growth, helps to keep the spongy, decayed wood saturated. In this decayed condition the sapwood dries out slowly.

Some species, such as chestnut and the oaks, decay very little in the heartwood until the sap has fallen away. This leaves comparatively small branches of dry heartwood exposed as a fire hazard for ten to fifteen years after a logging operation. If lopped so that these come in contact with the ground, they decay more rapidly.

The most significant fact brought out in the week's work was the distinctive character of heartwood and sapwood decay, caused usually by different species of fungi, and the long delayed infection of slash by heart rotting fungi, regardless of the dampness of the place where the slash was found.

This reconnaissance has shown the need for comprehensive studies and experiments relating to brush disposal. They should be conducted from the points of view of silvicultural efficiency and cost, the role of fungi and perhaps also of insects as disintegrating agencies, and the nature and rate of soil improvement.

#### Status and results of past studies in management

The past work in management has been largely exploratory, yielding quantitative results as to kinds and amounts of reproduction after different degrees of cutting. The emphasis has been on reproduction after cutting in the hardwood forest types, and it is in this study that the results so far obtained best indicate the probable trend of future studies. The situation thus revealed is as follows:

Hardwood reproduction on unburned cut-over areas is generally adequate in amount but inferior in composition, containing too small a proportion of the more desirable species. The proportion of seedlings to sprouts is large as compared with burned areas. The chief drawback to the further development of the reproduction into second-growth stands is the space occupied and the shade cast by large trees left standing when the cutting was done. If sound and straight and of good species, such trees may be worth more than the reproduction, but as a rule this is not the case.

Even before the data are worked up and analyzed, special problems can be recognized. For example, the reasons for the scarcity of several important species, such as cucumber and basswood, should be determined. Cheap and effective means should be found for improving the composition of existing reproduction by favoring the seedlings of the best species. Some species may be better adapted than others to sprout management, and this points to a study of sprout growth as compared with the growth of seedlings, and to experiments with sprouts and seedlings in mixture. The rate of increased growth of stems and crowns of trees released by cutting should be studied to determine the relative value of partial as compared with clean cutting, and of different degrees of partial cutting. Problems of brush disposal and eradication of underbrush prejudicial to reproduction have also been indicated, and others will be sure to arise when the survey data are compiled.

The permanent sample plots are already furnishing more definite information, though only for limited sets of conditions, than the survey data. The two are complementary. Permanent plots should be established in all major forest types and the results in reproduction and the growth of the larger trees reserved from cutting should be studied intensively. Many of the problems revealed in the survey will be subject to study in the permanent plots. Others, arising from both the survey and the permanent plots, will require intensive nursery, laboratory, and greenhouse study.

The investigations in thinnings are regarded as much less urgent than the other management work, to which they should be subordinated. The plans for the growth sample plots, discussed under mensuration, contemplate their use for thinning studies later on.

With only one year's progress the loblolly pine study has not yet gone far enough to justify a statement of results and tendencies other than that already given.

### Tree Studies

#### Southern white cedar

A study of the characteristics and requirements of southern white cedar - a locally important species of the Coastal Plain - was begun in 1921. The study dealt especially with the reproduction, growth, and yield of cedar under various environmental conditions. The work was undertaken largely because of the special interest of timberland owners and operators in the management of this species. It was conducted by C. F. Korstian, for the Station, in cooperation with the State foresters of Virginia, North Carolina, and New Jersey, and with cedar operators. The field work was carried into South Carolina, Georgia, Florida, Mississippi, and Alabama, and was finished in 1922. In the course of the study a shipment of southern white cedar logs was sent to the Forest Products Laboratory to be tested for the characteristics of the wood. W. D. Brush of the Washington office of the Forest Service made a trip into the cedar region of the Coastal Plain to gather data for a discussion of the utilization of cedar. This was included in the manuscript report.

Volume, growth, and yield data compiled from the results of this field work were sent to the cooperating State foresters of Virginia, North Carolina, and New Jersey. A bulletin embodying the results of the cooperative study in Virginia was published as Virginia Forestry Publication No. 30, "The White Cedar of the Dismal Swamp", by Alfred Akerman. A paper on "Natural Regeneration of Southern White Cedar" was read by Korstian at a meeting of the Ecological Society and published in Ecology (Vol. 5, pp. 188-191, April, 1924.). This paper was a preliminary treatment of one phase - seed storage - of the southern white cedar study. The completion of the bulletin was delayed by the demands of other work, and it was not finally submitted for publication until early in 1928.

#### Yellow poplar

Material for a bulletin on yellow poplar had been collected and assembled for publication some years previous to the establishment of the Station. This was turned over to the Station for additional data on regeneration, growth, volume, and yield of second growth stands. Field work to collect this information was started by E. F. McCarthy in 1921 and carried on as actively as work on other projects would permit in 1923 and 1925. About 80 temporary sample plots were measured in various parts of the region, and a trip into Ohio was made for cooperative work with the Mead Pulp and Paper Company. This work resulted in 120 complete stem analyses and 167 measurements of individual trees for volume tables. A determination of the solid contents of stacked poplar cordwood was also made; 9 cords of wood, cut from a one-third acre sample plot in which each tree was measured, were piled first as round, then as split pieces, and the contents per cord thus determined. Volume and yield tables were prepared from the field data in 1925.

A seeding experiment was started in 1923 at Willets, N. C., in cooperation with the Champion Fibre Company, to determine the feasibility of artificial regeneration of yellow poplar by direct seeding in seed spots and broadcast. When examined in 1924 every seed spot had one or more seedlings, but observations in 1927 (not made

by members of the Station) would indicate a more or less complete failure, attributed chiefly to frost heaving. This experiment was extended at Willets in 1925. Two permanent sample plots at Bent Creek, previously referred to in the discussion of the methods of cutting study (hardwoods), were established in 1925. The first draft of a bulletin on yellow poplar has been prepared by McCarthy and will be submitted for publication in 1928.

### The oaks

The oaks are collectively the most abundant and important species in the Southern Appalachian region. An uncompleted report on the more important species - white, chestnut, northern red, southern red, black, and scarlet oaks - was turned over to the Station, and a field study, conducted by E. F. McCarthy, was started in 1924. Three seasons' field work resulted in measurements of about 430 permanent sample plots for yield tables and several hundred tree measurements for volume tables. The latter were augmented by about 1,000 measurements loaned the Station by State Forester Besley, of Maryland; 1,000 contributed by State forester Secrest of Ohio; and 1370 furnished by the Yale School of Forestry and the Washington Office of the United States Forest Service.

Even-aged stands of oak old enough to furnish data on yield were found principally on areas where clean cuttings had previously been made for the production of charcoal. Old cuttings of this type are common in the iron-bearing parts of the region. Most of the plots were measured in Maryland and Virginia, but some were found in the other States of the Appalachian region.

This study was carried by Mr. McCarthy to the Central States Forest Experiment Station and has since been conducted by him in the States within the territory of that Station. A large amount of volume computation, however, was done at the Appalachian Station in 1926 and 1927, before the transfer. This Station has cooperated since then by the assignment of J. H. Buell to assist in further computation at Washington.

### Protection from fire

Fires have severely damaged large areas of Southern Appalachian timber lands, mostly cut-over by directly injuring large and medium-sized trees, killing forest reproduction, and altering the composition to the detriment of the stand. The organized efforts to prevent fires would be greatly helped if means could be found for predicting dangerous weather periods. These two considerations led to the initiation of two studies, one of fire damage, the other of forest fire weather.

### Forest fire damage

This study was started in 1922 to determine the extent of physical damage to existing stands and reproduction from forest fires. It was conducted by E. F. McCarthy. Areas which had suffered from fire were examined by a strip survey covering about 10 per cent of the area burned. Data were obtained as to the extent of killing, wounding, and recovery of the stands. A total of 311 acres of strip were run, with approximately two square rod sample plots to the acre for the determination of

the extent and character of the reproduction. This work was done in nearly all the States in the Station's territory, and a number of extensive and severe burns were examined.

The extensive survey was supplemented by the establishment of permanent sample plots to determine the rate and amount of continuing damage after fires. Two plots were established in 1923 on Pritchard Creek, on the Pisgah National Forest near Old Fort, N. C., and three - two in pine and one in hardwoods - on Bent Creek in 1925. These plots were put in soon after the fires and are being periodically examined to determine the final amount of mortality and injury. Some of them have been rather intensively studied by the entomologists at the Station to ascertain the amount of damage caused by insects.

Three permanent plots were established in the Boone division of the Pisgah National Forest after the unusually severe fire in the spring of 1926. The purpose of these plots is to keep a record of the growth rate of the reproduction and of the decay of fire-killed timber. Black locust, yellow poplar, and sassafras, grape, and other species whose seeds have hard coats were found growing in soil which had been so severely burned in the spring that seeds on the surface must have been consumed. Complete killing of all seed-trees makes it probable that the seeds were preserved in the top soil.

One outcome of the study of fire damage has been the determination, from the records of a number of fires of different degrees of severity, of the proportionate damage to various sizes of hardwoods. The data when scaled according to per cent of kill for the three inch diameter class showed a correlation of percentage of kill for the other diameter classes, which suggested that the per cent of kill for a given diameter class could be used as an index to the severity of the fire. The tabulated records for the 311 acres of strip covered in the study (representing over 2,800 acres of burned forest) show that any fire severe enough to kill 50 per cent of the three inch trees will kill practically all of the one inch trees, 73 per cent of the two inch, 34 per cent of the four inch, 22 per cent of the five inch, 15 per cent of the six inch, 11 per cent of the seven inch, 9 per cent of the eight inch, and proportionately less of all the larger trees down to about one per cent of the seventeen inch size class. Some of the larger trees are liable to be killed in any fire through the accidental occurrence of dead wood at their bases. The killing of the trees, however, does not damage the productive value of the forest as severely as the wounding of 30 or 40 per cent of the trees not killed.

A number of short articles containing results of this study were written by Mr. McCarthy and have been published. A general report on the work so far done is now being prepared for publication as a Government bulletin.

#### Forest fire weather

The practicability of forecasting periods of dangerous fire weather was undertaken by E. F. McCarthy in 1923 and 1924. Records of the dates of a large number of fires in the Southern Appalachians were correlated with the weather records for the two years and a close relation was found between the occurrence of fires, on the one hand, and periods of low humidity, on the other. Studies of U. S. weather maps showed

that in the majority of cases the dry periods could have been forecasted from the general direction of storm movement for periods up to three days before the occurrence of the dangerous weather conditions. The results of the study are contained in "Forest Fire Weather in the Southern Appalachians" and "Forest Fires and Storm Movement", written by Mr. McCarthy and published in the Monthly Weather Review for April, 1923, and May, 1924. The conclusions from the study are stated in the latter paper as follows:

"1. Weather conditions are of minor importance until the leaf crop is down.

"2. Heavy rains which pack the leaf litter retard its drying and make fire control easier.

"3. Dry periods occur after the passing of storms and with the advent of high pressure. This induces winds from the interior of the continent, which are dry; it brings lower temperatures, clear days, and lower absolute humidity. Day temperatures are high in spite of heat lost by radiation at night. The large diurnal range of temperature makes relative humidity low at midday.

"4. The Appalachian Plateau, by reason of its altitude and consequent radiation of heat, tends to induce a downward movement of air and retain high pressures.

"5. Disturbances which displace the pressure conditions at times of severe fire hazard commonly advance over Montana or Texas and the Gulf. Storms of the latter type are less frequent in the late fire season.

"6. The weather data collected daily by the Weather Bureau at Washington is broad enough to indicate such disturbances and the rate of movement with sufficient accuracy to forecast them at least three days in advance. This is not a marked departure from present Weather Bureau practice, since general weekly forecasts are now issued by this Bureau.

"The undertaking of forecasts for the specific purpose of aiding in forest-fire control will further research in this line and result in a concerted effort to increase the usefulness of such a service. Studies of storm movement at times of great fire hazard as shown by fire records will furnish the experience needed to fix the paths of storms during the brief periods involved.

"Field research should furnish a more accurate measure of successful prediction than chance fires by a study of the factors controlling leaf fall and the rate of drying of litter under varying conditions of the atmosphere."

The work in 1925 was accordingly directed to furnish more specific information upon the relation of weather changes to the dryness of the forest floor and its inflammability. The seasonal conditions affecting this are briefly as follows: Since the fuel supply of leaves during the fire season is a constant factor, fires can occur at any time when the weather conditions are favorable. The two fire seasons of the year, however, are in the spring, before the green vegetation has started, and in the fall, after the season's leaf crop is down. In the winter season dry conditions do not commonly continue long enough to create a serious fire hazard. In the

summer the drying out of the forest floor is prevented by the shade of the forest cover, and the increased humidity. Long periods of drought are not common in the summer season.

The study of inflammability was carried on during the fall fire season of 1925 and the spring season of 1926. Through the cooperation of District 7, of the Forest Service, a pair of recording hygrothermographs was obtained. These were set up at stations on north and south facing slopes at Bent Creek, along with rain gauges, and soil thermometers. A series of records was begun in the summer of 1925 by the Bureau of Entomology, which also maintained similar instruments at another station at Bent Creek. These records were continued during the late spring, summer, and fall of 1926 and 1927. The hygrograph records were checked by means of the sling psychrometer.

The records from October 1 to November 24, 1925, were kept by Mr. McCarthy in connection with his tests of inflammability of the litter. Rainfall, temperature, wind, and humidity were taken into consideration in the study of the moisture of the forest litter. The fall of 1925 was rather unsatisfactory for conclusive results, since there were few days when fire would run readily and no extensive period of fire hazard occurred. Determinations of the moisture content of leaves were continued during three days in March, 1926.

The results of the study are given in "Weather and Forest Inflammability in the Southern Appalachians", by E. F. McCarthy, in the Monthly Weather Review for March, 1927. McCarthy's conclusions given in this paper are as follows:

"After the fall of the new litter a fire hazard can be created through the agency of sun, wind, and low relative humidity on south exposures in a single day following a heavy precipitation.

"On north exposures during the fall season, due to the small angle of insolation and shade cast even by hardwood crowns, no material hazard can be created in one day.

"Wind is necessary for rapid drying, especially on north exposures.

"Leaves absorb more than their dry weight of water and absorb moisture from moist air without the agency of rain, dew, or frost. The moisture content of litter is thus affected by night humidities.

"The period of active drying during the fall season of 1925 was limited to 6 or 7 hours during midday even on the more hazardous days. High relative humidity was common throughout all nights after the leaf crop came down.

"Low moisture content can be estimated by a breaking test.

"The conclusions from the fall season of 1925, as regards drying rate on south slopes, were generally verified in the spring season, although lower moisture percentages were found.

"Conditions of wind, sunshine, and relative humidity favorable to forest fire

are the regular aftermath of the passage of a storm, and can be forecast with more certainty than precipitation.

"Unusual hazard is caused by continuation of high pressure over or west of the Appalachian region, or by the passing of a storm without precipitation in the region."

The "breaking test" referred to is described by McCarthy as follows:

"In order to provide a field method for the determination of moisture content of the litter, about 50 determinations were made by weighing and correlated with series of breaking tests. While the heavier leaves, such as those of the post oak, crack or break with higher moisture content than the thinner leaves, such as white oak, the amount of this variation is not great. The following relations express the average results of these tests:

"Leaves having 20 to 40 per cent moisture crack if creased, but do not break entirely.

"With from 14 to 20 per cent moisture they crack if folded more than a right angle.

"At an average of 14 per cent moisture they crack when bent at a right angle, but do not break freely, especially in the veins.

"At an average of 10 per cent moisture they break entirely apart if bent at a right angle. Litter at 10 per cent moisture breaks up if crushed in the hand, but does not crumble into small pieces.

"Freshly fallen leaves are tougher at any given moisture content than those which have been dried and saturated again."

#### Protection from Grazing

At the time of the establishment of the Station some instances of damage to forest reproduction as a result of grazing had been noted and it was decided to attempt to ascertain the extent of such damage and the conditions under which it was most severe. Two sets of three fenced sample plots each were accordingly established on grazed areas on tributaries of Curtis Creek, Pisgah National Forest, in the spring of 1922. The work was assigned to F. W. Haasis, who made field trips on the study and established another plot on Hone Quarry Run, Shenandoah National Forest, in 1923.

It soon began to appear that woods grazing in the mountain region was not as prevalent nor as injurious (except in small, widely scattered areas) as had been supposed. The advisability of continuing the study was questioned in view of the other important subjects demanding attention. It was decided to let its continuance depend upon the results of a questionnaire as to the number of stock grazed in the woods, the importance of forest grazing, and whether it is increasing or decreasing in importance. The questionnaire was sent in 1925 to grazing specialists at the agricultural experiment stations in the region, forest supervisors, county agricultural

agents, and others. From the reports received, which covered 32 counties well distributed through the region, it appeared that forest grazing is not very important as to number of stock grazed and that, for the most part, it is steadily decreasing in importance. Relatively few counties reported either increases, stationary conditions, or merely slight decreases. The cancellation of the project was therefore recommended in the Station's program for 1926, and approved.

The results of the questionnaire are contained in "The Decreasing Importance of Forest Grazing in the Southern Appalachian Region", by F. W. Haasis, in *Journal of Forestry*, Vol. 14, page 533, May, 1926. The permanent sample plots established in this study are being continued under the study of natural reproduction after different methods of cutting (hardwoods).

#### Forest Insect Investigations

In 1925 entomological work was begun at the Station with the temporary assignment of R. A. St. George, in charge of the East Falls Church Station of the Division of Forest Insect Investigations, Bureau of Entomology. Studies outlined by Dr. F. C. Craighead, Chief of the Division, were started by Mr. St. George assisted by A. H. MacAndrews and later in the summer by William Middleton and James A. Beal. In 1926 Mr. St. George resumed his work at Falls Church and Mr. Beal was permanently assigned to the work at the Appalachian Station.

The most destructive insect in the pine stands of the South is the southern pine beetle (*DENDROCTONUS FRONTALIS*), which has been responsible in the past for enormous losses of pine timber of various species. The entomological work has therefore centered around a study of the southern pine beetle in order to determine its vulnerable points and devise means of combating it. To determine the relation of drought to bark beetle attack, three trenched sample plots were established in 1925 in a second-growth shortleaf pine stand at Bent Creek and completely roofed over with paraffined muslin, which was replaced in 1926 with balloon cloth. Two MacDougal dendrographs were installed to measure the growth in diameter of the trees, continuous records of air humidity and temperature were kept by means of self-recording instruments, and regular observations were made of soil temperature. Outside of these plots many other observations and experiments were systematically undertaken, and several of the permanent sample plots established in the study of fire damage were used as means of obtaining entomological information.

The study of environmental factors governing epidemics of the southern pine beetle were continued in 1926 and 1927, and much information was collected upon the biology of this beetle and associated species, parasites, and enemies. Beetles were caged for observation as to breeding habits, both on the trees themselves and in insectaries built for the purpose. Seasonal cuttings, started in 1925 in an attempt to attract beetles, were continued in 1926. In an effort to determine the precise cause of death from beetle attack as contrasted with that following girdling, tree injections were made with sodium arsenite. The first results seem to indicate a closer resemblance in death phenomena between poison and insect attack than between girdling and insects. Injection experiments have since been started with a number of other substances.

An interesting observation was made by Beal in January 1927, as to the death of southern pine beetle larvae, dormant under the bark, as a result of frost. The temperature dropped suddenly, on January 14-15, from about 50 to only 7 degrees above zero. On January 18 it was noted that all of the brood examined which were alive at the last examination, had apparently been killed. Later observations showed a severe mortality not only of the mature larvae but also of the pupae and adult insects which were over-wintering in the cambium zone and inner bark of pines in the vicinity of Asheville. The only southern pine beetles which seemed to have survived the winter were those which were in the egg stage. These were feeding normally in the cages at the Bent Creek laboratory in the early part of April.

Numerous severe attacks of insects upon hardwood species have been brought to the attention of the Station within the last two years. An attack of the hickory bark beetle (*ECCOPTOGASTER QUADRISPINOSUS*) was discovered in 1927 at Swannanoa, N.C., and a large number of oaks, chiefly scarlet oak, have been dying throughout the Southern Appalachian region. Most of the oak trees attacked are mature and of somewhat slow growth. All those examined have contained more or less evidence of recurring attacks of *PRIONOXYSTUS ROBINIAE* and a great deal of damage has been done to both the limbs and the trunks.

In all cases a species of *AGRILUS* was found working under the bark and this work often completely surrounded the trunk from the base to the crown. It seems probable that the death of the hardwoods from insect attack may be traced to their weakened condition as a result of the severe drought of 1925. A further source of weakness, favoring insect attack, may have been the very heavy late frost of April 23, 1927.

#### Studies in Forest Pathology

Dr. C. J. Humphrey was assigned as pathologist at the Station in July, 1925, this place having been specially provided by Congressional action. Because of Dr. Humphrey's previous experience with the deterioration of pulp-wood, his first work was a study of the effect of decay of chestnut extract wood upon the tannin content with G. F. Gravatt of the Washington Office. One result of this investigation would be the determination of the probable reduction of tannin content of blight-killed chestnut trees left standing for a considerable length of time. A conference of representatives of the extract industry was held at Asheville to formulate plans for the study. Other conferences were held with chemists, preliminary tests were made, and a plan for a cooperative study of the tannin content of dead and decayed chestnut wood was prepared and distributed in 1925.

Dr. Humphrey resigned in March, 1926, to accept a position as pathologist under the Philippine Government. Dr. G. G. Hedcock was appointed temporarily in 1926 as Station pathologist to take Dr. Humphrey's place. Dr. Hedcock conducted studies of heart rots of standing timber in the Southern Appalachians and of infection through injuries, principally fire scars. Most of the work was on yellow poplar and the oaks.

R. M. Nelson started on the tannin and other phases of the chestnut study in June, 1926. He reported to the Station in April, 1927, to take charge of pathological work. The tannin study was enlarged and more than 300 specimens were collected,

ground up, numbered, and distributed to the cooperating chemists of the extract plants for analysis. The study has been completed by G. F. Gravatt and R. M. Nelson and the results are now being prepared for publication.

In addition to continuing tannin studies, Mr. Nelson started experiments in the Station forest at Bent Creek on the rate of checking and other deterioration of chestnut. Some chestnut trees were felled and others were girdled at different seasons in order to get comparative records on checking and decay. An experiment was also started to ascertain the rate of mortality of sprouts from the chestnut blight.

Mr. Nelson also took an active part in the survey to determine the rate of spread of the chestnut blight. An 80 per cent infection has been found in 21 counties of West Virginia, 7 of North Carolina, 2 of South Carolina, 2 of Georgia, and all but 14 of the important chestnut producing counties of western Virginia. In these States and in Kentucky and Tennessee, within the region in which chestnut is important, 69 counties have from 30 to 79 per cent of the chestnut trees infected; 62 have from 10 to 29 per cent infected; and only 23 have less than 10 per cent. It is predicted that within the next ten years the blight will kill most of the chestnut timber in the Southern Appalachian region. Owners have been warned to salvage their chestnut timber early so as to avoid the effects of a glut of chestnut on the market, or its loss through death and decay, which may be expected as the blight spreads and intensifies.

#### Weather

Local weather conditions - sleet storms, frost, drought, wind, and lightning - are responsible for various kinds of direct and indirect damage to the forest. Bad fire periods coincide with certain weather conditions and can be forecasted. Frosts destroy native as well as planted seedlings by heaving. Frost and drought may weaken the resistance of trees so that they soon fall victims of insect attacks. A drought at the time of planting may be the cause of a heavy mortality of the planted stock, while a protracted drought may even kill outright full-grown forest trees.

An exceptional drought in 1925 resulted in the browning and apparent death of large numbers of forest trees. Weather Bureau records for Asheville showed a deficit of about 18 inches below the normal precipitation of about 40 inches. This deficit occurred mostly in the summers. The damage to the timber occurred in conspicuous strips and patches, chiefly on the upper slopes of ridges. It presented an unusual opportunity to learn something about the extremes of endurance of different tree species under different conditions, which would add to the knowledge of their growth requirements. A study of the effects of the drought upon the affected trees was accordingly begun in 1925, by F. W. Haasis. One hundred trees in the Bent Creek experimental forest, about half of them affected by the drought and half not visibly affected, were tagged and detailed records were made of them. Soil samples were taken at various depths, in each group of trees studied, for the determination of the moisture content. To a depth of a foot or more the soil dried out to a moisture content of 5 or 10 per cent, and was so dry it could not be brought up by the soil auger. In the spring of 1926 the soil moisture content was mostly between 15 and 30 per cent. The main root layer in this locality is very shallow. There are few roots and little humus below a depth of about a foot.

Examinations made in June, 1926, showed some recovery. Most of the trees which lost their leaves early in the fall of 1925 were found to be growing, but many of them had dead tops. Some were sending out basal sprouts, while on others the only green branches were those produced in 1926, sometimes near the base of the tree and sometimes all along the bole. Some suppressed trees, released by the death of the tops of large, overshadowing trees, were making good growth. Apparently, however, the loss through the permanent crippling of trees has been severe. Another examination will be made during the coming summer.

The relation of climatic factors to the geographical and altitudinal distribution of tree species, the germination of seed, survival of reproduction, abundance of forest insects, and other subjects under investigation by the experiment station gives special importance to weather records made at points which are reasonably representative of conditions in adjacent forested country. Unfortunately most of the weather stations are in cities. In order to determine the climatic conditions which prevail at high altitudes in the Southern Appalachian region the Station participated, in August, 1922, in the establishment of a cooperative weather station at the top of Mount Mitchell. This weather station, at an altitude of about 6,700 feet, is the highest east of the Mississippi River. Observations are made daily during all but the winter season by the cooperative lookout maintained by the State and the Federal Government. These observations are indicative for the spruce-fir type and are useful in connection with the planting experiments at the high altitudes, as well as in rounding out the knowledge of the climatic factors for the entire region. It is noteworthy that simultaneous with a temperature of -5°F. at Asheville, a minimum of -25°F. has occurred on Mount Mitchell, 39 miles away.

#### Forestation

The Southern Appalachian forests reproduce naturally after cutting and even after fire, and planting is therefore much more rarely necessary than in many other forest regions of the country. In the spruce type, however, fires are fatal to the spruce and fir reproduction (as indicated in the discussion of natural reproduction in the spruce-fir forest) and the only way to ensure a valuable new stand on burned-over spruce land is by planting. Outside of the spruce type, the artificial reforestation of cleared lands, from which the forest growth has been eradicated by cultivation, will also call for some planting. The Station has accordingly carried, as minor studies, some experiments in planting in the spruce-fir type and in the hard-wood types. These experiments have dealt chiefly with tests of various native and exotic species grown in nursery seed-beds and set out as transplants.

The large forest plantations in the Biltmore Estate, at Biltmore, N.C., presented an excellent opportunity to gather information upon the success or failure of various planted species. This suggested a study of the Biltmore Plantations. Another study, of all other plantations in the region, was also undertaken.

#### The Biltmore Plantations

The object of this study, which was begun by F. W. Haasis in 1921, was to collect all available data on the history of the plantations established by Dr. C. A. Schenck and others on the Biltmore Estate, and to convey a general idea of the sub-

sequent growth and present condition of each plantation. Most of the original records of the plantations had been lost, so that considerable difficulty was experienced in getting together the information. A voluminous report, with location maps, was finally prepared, however, in which each of the 87 planted stands studied is discussed historically and as to its present condition. Parts of this report, containing detailed information about the several plantations, were mimeographed and distributed by the Station in 1925. A manuscript for a general circular on the plantations has been submitted for publication.

### General study of plantations

A great deal is to be learned from plantations as to species and methods to be tried or avoided in future planting. The general study of plantations was begun in 1921 as a minor project, for work as opportunities arose. F. W. Haasis was placed in charge of it, although other members of the staff were expected to contribute. Reports by Haasis on the Consolidation Coal Companies plantation in eastern Kentucky, and by Korstian on the results of the direct seeding done in 1907 by Rothkugel near Winterburn, West Virginia, were submitted in 1922. In 1926 Haasis established a permanent sample plot in a 15-year-old plantation of Virginia pine in the Berea College tract, tagging and measuring about 400 trees. During the same year, Haasis, in company with State Forester F. B. Merrill of Kentucky, visited and obtained records of a number of plantations of yellow poplar, catalpa, and black walnut, 15 or 20 years old, near Pineville, Richmond, and Earlington, Kentucky. It is expected that a record of all plantations in the region will thus be gradually built up.

### Tests of species for planting

Experiments to determine the species best suited for planting in the spruce-fir type were begun on slopes of Clingman's Peak, in the Black Mountains of North Carolina, in March, 1923, and have been continued each spring with additional plots. The work has been conducted by C. F. Korstian. The area originally supported a heavy growth of red spruce and southern balsam fir. Fires which followed the logging destroyed practically all softwood seedlings. The light snowfall and exposure to severe winter winds now present an unfavorable site for the establishment of a new stand. The sites selected for the larger blocks of experimental plots were a south and an east facing slope, at an elevation of between 5,500 and 6,000 feet, on which the heavy growth of fire cherry and yellow birch prevalent over large areas, was absent.

The following species have been planted in chain-square plots, each plot containing 100 transplants:

YEAR	NUMBER OF PLOTS	SPECIES
1923	11	Norway spruce, Douglas fir, western white pine, Japanese black pine, pitch pine.
1924	17	Red spruce, Norway spruce, white spruce, southern balsam fir, European silver fir, Japanese larch, European larch, western white pine, Japanese red pine.
1925	6	Norway spruce, red spruce, southern balsam fir.
1926	13	Northern white cedar, Japanese larch, lodgepole pine, Norway pine, Scotch pine.
1927	6	White spruce, white fir, western white pine, Japanese red pine.

Examinations of the plots have been made annually, and height growth records were begun in 1924. Four of the plots planted in 1926 are in the State Park at or near the top of Mount Mitchell. The Station's planting experiments have usually been done at the time of larger planting operations in the Black Mountains by the Pisgah National Forest. These larger plantings now cover about 270 acres. They consist almost entirely of Norway and red spruce.

Of the species tried by the Station the most successful, according to the examination made in November, 1927, have been the native red spruce and southern balsam fir, with pitch pine, Norway pine, and Norway spruce following in order. The larches have failed entirely, though the failure may be attributed to poor planting stock. Most of the planting has been done on areas not covered by brush or hardwood reproduction. In April 1925, however, 100 red spruce transplants were planted under a dense growth of hardwood saplings, chiefly fire cherry. When observed in November, 1927, 34 of these were dead. It is possible that the severe drought of 1925 was chiefly responsible, although the plots on the open land appeared to have suffered little if not at all. The drought was probably more effective under the hardwood cover than in the open due to the intense root competition of the hardwoods for soil moisture.

Other experimental plantings, with small amounts of Norway spruce transplant stock supplied by the Station, were made in 1923 by the North Carolina State Forester, on Mount Mitchell, and by the Pfister and Vogel Leather Company, on Brasstown Bald, near Young Harris, Georgia.

Seed spots of one native and six exotic conifers were put out on Clingman's Peak in 1923. They were an entire failure.

In 1923 the Champion Fibre Company established a nursery at Canton, N. C., and by agreement with the Company the Station was allowed the use of some of the seed beds for growing stock for experimental plantings. For the latter purpose seed of the following species have been sown:

1923. Sitka spruce, white spruce, Douglas fir, southern balsam, fir, southern white cedar, Japanese larch, Japanese red pine, western white pine.

1925. Red spruce, white spruce, noble fir, incense cedar, Japanese red pine, and other conifers.

1926. Korean fir, Japanese larch, Japanese red pine, sugar pine, Monterey pine (seed from New Zealand).

1927. White spruce, Engelmann spruce, Douglas fir, western larch, Japanese larch, western red cedar, western hemlock, bigtree, bristlecone pine, western white pine, sugar pine, Monterey pine, Norway pine.

The western white pine, white spruce, and Japanese red pine transplants set out on Clingman's Peak in 1927 were raised in the Canton nursery.

In the Canton nursery, also, attempts have been made to raise from seed a number of foreign hardwood species. Seed of 12 Chinese species of chestnut, *CASTANOPSIS*,

and oak collected by J. F. Rock in Yunnan Province, China; three species of EUCALYPTUS from high altitudes in Australia; and an alder (*ALNUS NEPALENSIS*) were sown in 1923. Five species of EUCALYPTUS from New Zealand were tried in 1924. All these attempts were complete failures, the species being unable to survive the winters.

About 180 plants of a chinese tree chinquapin (*CASTANOPSIS DELAVAYI*), grown in the Bureau of Plant Industry nurseries at Bell, Md., from seed collected by J. F. Rock in Yunnan Province, China, were set out in 1925, at Bent Creek and in Asheville, N. C. In spite of mulching, all but one of these died during the first winter, and not one now remains alive. About 30 transplants of the Chinese hairy chestnut from the Bell, Md., nurseries were set out at Bent Creek in 1926. These are still living but their growth has been poor. In 1926, also, the Station received 34 transplants and about a pound of the fruit of *RHAMNUS PURSHIANA* from the biological department of Eli Lilly and Company, Greenfield, Ind. The transplants are making fair growth at Bent Creek and Biltmore, N. C.

The discovery a few years ago of Norway pine in West Virginia suggested its trial in other parts of the Appalachian region. In addition to that which was planted on Clingman's Peak a trial was made in 1926 on various sites at Bent Creek. Stock was received from the New Hampshire and Vermont State nurseries, from the Pennsylvania State Forest School at Mont Alto, and from the Cloquet (Minn.) Forest Experiment Station, so that comparative results may be expected from the plantings. Sugar maple and northern white cedar transplants, from Cornell University, lodgepole pine, Scotch pine, and white fir were also set out in 1926 at Bent Creek. These experimental planting plots at Bent Creek were increased in 1927 by small plots of sitka spruce, Norway pine, western white pine, incense cedar, lodgepole pine, southern and northern white cedar, and sugar maple.

In the fall of 1926 there was a heavy crop of red spruce and southern balsam fir seed in the Black Mountains, and a supply was obtained by a field party from the Station. Several pounds of this seed were distributed to cooperators and some was sown in seed beds at Canton and Bent Creek in 1927, along with yellow poplar seed collected in 1926. Some of the spruce and fir seed was held over for subsequent planting.

In order to try out the Bent Creek bottoms as to nursery possibilities, small seed and transplant beds were established there in 1927, in three locations. Species were used which would require the least amount of water and care, the principal purpose of the experiment being to determine whether or not frosts will be too severe for the successful raising of experimental planting stock.

Experiments in the control of weeds by formaldehyde and of damping off by copper stearate, sulphuric acid, and zinc chloride were tried in the Canton seed beds in 1925, in cooperation with Messrs. Hartley and Hahn, of the Office of Forest Pathology, Bureau of Plant Industry.

#### Forest Mensuration

Forest measurements enter into nearly all of the investigations at the Station. The heading of Forest Mensuration is maintained to cover certain special studies of which measurement is the outstanding purpose.

The Station has carried only one such study, growth sample plots, which was started in 1926. The purpose of this study is to determine by observations of the growth in measured sample plots (1) rotation ages for different species and products, (2) relation of site to growth rate, (3) relation of crown condition to growth rate, and (4) the best stocking of stands, and the relation of different conditions of stocking to the future growth.

These items suggest thinnings and cleanings, which will probably be undertaken as the stands grow. In fact, much of the work contemplated will later be distributed under other heads. Since the first task is to establish permanent sample plots for the study of growth, the ultimate purposes, which are broadly comprehensive, can be best carried, for the time, under the one study.

In 1926 two permanent plots of four-tenths acre each were established on Star Gap Branch, Pisgah National Forest. All trees down to  $\frac{1}{2}$  inch diameter, breast high, were tallied on eight sub-plots of four square rods each, and the heights of average dominant trees were measured. The oldest trees were six years old, but the stocking was irregular. In 1926, also, two half-acre plots were laid out in scattered juvenile forest growth in the Berea College tract. The site is an old field, abandoned 6 or 7 years ago. As in the Star Gap plots, tallies were made on eight sub-plots of four square rods each.

These plots are being established in juvenile stands on cut-over or burned areas. It is believed that there should be hundreds of such plots, well distributed with reference to site, composition, and condition of stocking, since they will afford the best possible means of determining the growth rate of stands and their development under treatment as well as under natural conditions. The plots should be laid out in groups so that one or more can later be treated and one left as control. While very young the trees should be tallied, according to species, diameter breast high, crown class, and height, on at least a measured part of each plot. Later each tree should be tagged. Plots should be established in understocked as well as in fully-stocked second-growth and should be allowed to run for periods of 50 years or longer, with remeasurements every 5 years, perhaps oftener while the stand is very young and rapidly changing in number of stems.

### Miscellaneous

#### Site studies

A study of site classification by means of height growth was carried by the Station in 1922-1925, to continue the work started by Frothingham and Watson which led to a tentative classification of southern upland hardwood sites on the basis of curves with standard height growth intervals of 20 feet at 100 years (preliminary results contained in "Site Determination and Yield Forecasts in the Southern Appalachians" and "Classifying Forest Sites by Height Growth", by E. H. Frothingham. *Journal of Forestry*, 19; 1,374- 1921). The project was discontinued in view of the active work on this subject by the Washington Office. A site index method of classification has been adopted by the Forest Service whereby the sites are classified on the basis of the height of dominant trees at 50 years of age. Uniform intervals of 10 feet of height at 50 years are used.

### Type studies

In 1924 a classification of forest types in the Southern Appalachian Mountains and Plateaus and the northern Coastal Plain was prepared by a committee of the Southern Appalachian Section of the Society of American Foresters. Three of the five on this committee were members of the Station staff. This classification was approved by the Section and printed in the Journal of Forestry for October, 1926. Twenty-seven types are recognized: 14 in the mountains, 6 on the plateaus, and 7 on the Coastal Plain. This classification is intended merely as a preliminary to later classification as a result of more thorough-going study of forest composition as related to environment than is possible at the present time.

### Numbering permanent sample plots

A standard method of numbering permanent sample plots was adopted in 1926 following correspondence with a number of the other forest experiment stations. A single numerical series for all plots in a single locality was decided upon. For a given locality the number is all that will be necessary for identification, although the project symbol may also be attached. Plots established in the entomological and pathological investigations may be numbered in a single separate series with a key letter for identification in addition to any other symbols.

## INVESTIGATIVE PROGRAM OF THE STATION

### Some Administrative Needs and Tendencies

#### Cooperation

One of the most promising developments of the last year or two has been the increased efficiency of cooperation between the different investigative agencies at the Station. The inter-relation of problems has been shown in the case of blue stain and pine bark beetles, insects as a factor in controlling the composition of stands containing shortleaf and other yellow pines, pathological menace to white pine plantations, dissipation of seed crops by rodents, and many other relations. The size of the field for cooperation and the benefit to be gained by it are becoming more and more apparent.

The prospect of increased cooperation in 1928, from two additional sources, is therefore highly gratifying. The Appalachian Forest Research Council, at its meeting last October, passed strong resolutions that studies in wood utilization and in the relations of game and other animals to the management of the forest should be undertaken in the Appalachian region. These recommendations were favorably received and a beginning is to be made during the coming season in both lines of investigation. A cooperative mill-scale study will be undertaken by the Forest Products Laboratory, the eastern National Forest administrative district of the Forest Service, and the Appalachian Forest Experiment Station and its cooperators, and the U. S. Biological Survey has agreed to make a preliminary study of animal problems this spring, which it is hoped will lead to active and continuous work in the region.

Two other lines of cooperative investigation that have been recommended by the Research Council are, first, the problem of forecasting forest fire weather, suggested

for study by the U. S. Weather Bureau; and second, a broadly cooperative investigation of forest cover in relation to flood control and the silting of reservoirs. A third need is for cooperation with the Bureau of Soils in studies of forest soils. It is to be hoped that these lines of investigation will soon be added to the cooperative activities at the Station.

#### Need of more working centers

The growth of these activities emphasizes the need for a larger number of working centers at which experiments continuing over a period of years may be grouped. Suitable working centers are not easily found. Their forest conditions must be representative for large areas of forest land to which the investigative results can be safely applied. Permanent tenure of the land must be guaranteed, together with reasonable protection against fire and other destructive agencies. Satisfactory living and working quarters must be provided within easy access of the various sample plots established.

The broken topography of the Southern Appalachians produces such variations in soil, climate, and forest type that relative uniformity can be found only on small areas. In any locality of the limited size desirable for a working center, it seems impossible to find the ideal combination of uniformity and variety which would make the locality thoroughly representative of the conditions to be found over an extensive area. Furthermore, the area in some of the types is commonly too small to accommodate all the sample plots needed, even if these should be reduced to less than the most desirable size. As a Station development for the near future, therefore, it seems necessary that more working centers be found and that there should eventually be several of these within each major topographical unit of the region, in addition to the present branch stations.

It has been suggested that one or two such centers might be located to advantage along the main automobile roads over which field parties from the Station will travel to and from the branch stations. The National Forests offer permanent tenure and protection, and of these the Unaka and Natural Bridge may well be considered because of conditions presented for study as well as of accessibility on travel routes.

Attention should be given in 1928 to the Robinson sub-station of the Kentucky Agricultural Experiment Station as a place for work by the Appalachian Station and its cooperators. The headquarters of the sub-station are at Quicksand, Ky., in Breathitt County, and it may perhaps be considered in connection with the work at Berea.

In the Coastal Plain, the Lee National Forest, near Petersburg, Va., appears to have all the features of a desirable branch station. With an area of about 7,000 acres, it bears even-aged stands of loblolly pine of many age classes, which present very favorable opportunities for experiments of different kinds, and some, in thinning, have already been started. Several hundred acres of cleared land are available for planting and there are about 200 acres of swamp hardwoods. Recommendations for the development of the Lee as a branch station will be made in 1928.

In connection with branch stations and working centers, efforts should be made to find tracts of virgin forest suitable for reservation as natural areas in which successional changes can be observed as a standard for comparison with treated forest.

#### Extension of work to South Carolina

South Carolina has been added to the Station's territory because of the ease of access from Asheville. The work previously carried on in the Coastal Plain region by the Southern Forest Experimental Station will be continued by the Appalachian Station, and the latter will extend to South Carolina its studies in the mountain and Piedmont regions. Preliminary trips to establish contacts and work out plans for investigations will be made during the year.

#### Trend of Future Investigations

#### An extended program of work for the Station

To direct each year's work to best advantage, a program of work drawn up for five or ten years in advance should be of great service. As a general station activity for 1928 it is proposed to prepare such a plan. It should be based upon the practical needs for the results of research and should take into account the special requirements of the various industries using wood or dependent upon the forest in one way or another - such as the lumber and wood pulp industries, coal mining, railroads, tanning, game management, the development of water power, and the manufacture of wood utensils and other small products - where such special requirements will influence the general management of stands. It should also provide for an increasing intensity and precision of investigations.

Some of the past work of the Station has been general and exploratory, to supply more or less empirical results for immediate use, as in the case of the general growth rate of forests, the tendency of reproduction on cut-over lands, etc. While similar work will probably have to be carried on to some extent in the future, it is never fully conclusive and should be supplanted as rapidly as possible by fundamental studies. Such studies will provide a basis of proved fact upon which silvicultural practice can be built up with assurance. The extended program for the Station should therefore involve an increasing application to fundamental work to be conducted by specialists.

As an illustration of the kind and number of subjects demanding investigation, the following can be listed under the general topic of forest management (Hardwoods). Some of these are new while others have already been started but should be carried much further:

- a. Factors which favor and hinder the active reproduction of desirable species.
- b. Methods of economically controlling the composition of young stands.
- c. Effects of different methods of slash disposal upon soil and reproduction.
- d. Methods of eradicating undergrowth which is prejudicial to forest reproduction.
- e. Development of an understory of shade tolerant trees to increase the yield of the forest.

- f. Methods and effects of eradicating defective and unmerchantable trees.
- g. Renovation of fire-damaged young stands.
- h. Methods and feasibility of converting poor hardwoods on dry sites to pine or mixed pine and hardwoods.
- i. Function and desirability of living ground cover and understory.
- j. More intensive studies of the results of various methods of thinning in increasing the amount and value of the yield.
- k. Classification of trees with respect to vigor of growth and seed production.

The other investigative subjects on the Station's program have been subdivided in the same way. For the subjects of natural hardwood reproduction, artificial re-forestation, and growth, synopses of the basic problems have been prepared. It is planned to make similar analyses of the other general subjects - particularly protection and mensuration - as well as of subjects not yet included in the Station's program, such as forests and stream run-off, and the study of forest soils. A fair start has already been made, however, toward the development of an extended program which will bring out new and needed investigations and clearly indicate the size of the field for the Station's activities.

Among the activities which should claim attention in the near future, three are worthy of particular mention. These relate to forests and run-off, forest soils, and observations of the time of budding, leafing, flowering, and fruiting of forest trees.

#### Forests, stream-flow, and erosion

The relation of forests to the rapidity of the water run-off, of erosion, and of the silting up of stream channels and reservoirs, has never been studied systematically in the Southern Appalachians. The Appalachian Forest Research Council at its meeting in October, 1927, called attention to the need of such studies by a resolution pointing out the lack of definite information and urging that steps be taken to solve this problem through the concerted action of different organizations. Such studies will cover a considerable period of time and will require the full attention of a specialized corps of men. They should be cooperative between the experiment station and such agencies as the Geological Survey, the Weather Bureau, and others. Pending the taking up of this work the Appalachian Station will attempt to find suitably paired small drainage areas in which comparative studies can be made.

#### Soils studies

In 1927 the Station was fortunate in having a visit from Dr. Henrik Hesselman, Director of the Swedish Forest Experiment Station and one of the world's foremost soils scientists. His visit was enlightening as to the great desirability of fundamental work in forest soils at the Appalachian Station. While the Station is not prepared to embark on a comprehensive study of the forest soils of the region - involving complicated physical, chemical, and biological aspects - a beginning is recommended for 1928 in the form of a study of fire damage to forest soils. It is also recommended that a soils specialist from the Bureau of Soils be assigned to the region for the purpose of making soils determinations and maps at one or two of the branch stations and perhaps at other points.

### Phenological studies

The determination of the time of budding, leafing, flowering, and fruiting of forest trees is important for several practical aspects of forestry and is fundamental for investigative work in forest reproduction. To obtain adequate records for the important Southern Appalachian tree species, at different points in the region and under different conditions of altitude and exposure, will require a high degree of co-operation, through a long period of years, with interested and reliable observers throughout the region. The work should be supplemented by climatic records obtained by weather stations near the points of observation. It will doubtless have to be entered on a small scale and gradually built up. During 1928 it is proposed to work out a plan for such a study.

### Mill-Scale Study of Southern Pines

A mill-scale study of southern pines, especially loblolly pine, is needed as a logical sequel to the Station's study of reproduction and growth of loblolly pine after cutting. Such a study will have two important results. It will supply data on the sizes of trees which can be removed profitably for lumber. Many trees are commonly cut for saw-logs that are probably much too small to pay their way out of the woods. The only satisfactory way to determine what sizes can be profitably logged is to follow marked logs from different sized trees through the mill, determine the grades of lumber produced, and their values at the mill, and weigh against these values the costs of logging and milling. This study will also yield much needed information on the extent and character of decay and insect damage.

This study is recommended for next year's program. Because of the difficulty of organizing forces for this work it is urged that plans be made for it, for the calendar year 1929, with the Forest Products Laboratory, District 7, the Office of Forest Pathology, and the Division of Forest Insect Investigations, and that the other saw-mill operators be canvassed for suitable opportunities for cooperation.

### Cooperative planting experiments in Virginia

The Station has been asked to take part in planting experiments to be undertaken by the State Forester of Virginia, in cooperation with the National Forests. This will be done to the extent that a man from the Station's staff can be spared for the work.

### Fire statistics

Much information about forest fires can undoubtedly be gained from a detailed analysis of fire statistics collected by the State Forestry Departments. This work will not be undertaken in 1928, but it is felt that the advantages of such an analysis are such as to justify a very thorough study at an early date.

## PLANS FOR 1928

Of the 21 projects on the investigative program for 1928, four are to be completed during the year with manuscripts for publication, one will probably be finished with a little more field work in 1928, and one will be held inactive for the present. Two are cooperative, involving participation by the Station in projects carried by other units of the Forest Service..

### Projects to be closed in 1928.

TIMBER GROWING AND LOGGING PRACTICE IN THE SOUTHERN APPALACHIANS. Manuscript for a bulletin by Frothingham and McCarthy nearly finished.

SOUTHERN WHITE CEDAR: ITS CHARACTERISTICS, GROWTH, AND MANAGEMENT. Manuscript for a bulletin has been completed by Korstian.

YELLOW POPLAR: ITS CHARACTERISTICS, GROWTH, AND MANAGEMENT. Manuscript for a bulletin now being revised by McCarthy for publication.

NATURAL REPRODUCTION IN THE SPRUCE TYPE. Manuscript to be prepared by Korstian for publication from data already compiled.

GERMINATION AND EARLY SURVIVAL IN OAKS. Report by Korstian published by Yale University in 1927. Additional minor experiments to be finished in 1928 if time is available.

### Inactive project

THINNINGS IN LOBLOLLY PINE. Inactive pending formulation of plans for Coastal Plain studies.

### Active projects

The following activities are recommended for 1928:

#### A. Management

METHODS OF CUTTING AND NATURAL REPRODUCTION - HARDWOODS. Continuation of extensive survey begun last year. Examination and remeasurement of plots at branch stations and establishment of new ones as opportunity offers. Phases of the study to receive special attention are: (a) seed production of important hardwoods; (b) preparation of plans for collecting data on time of budding, leafing, flowering and fruiting; (c) classification of trees with reference to vigor; and (d) rate of disintegration of logging slash. The project will be assigned to E. H. Frothingham, F. W. Haasis, and J. H. Buell, with assistance of other members of the staff. A report on the survey phase to be prepared in 1929.

REPRODUCTION, GROWTH, AND MANAGEMENT OF LOBLOLLY PINE. Data collected last year, and transferred to punch cards, to be classified, and any gaps found to be filled by a survey this fall. The study should be extended to South Carolina.

Permanent sample plots to be established, as opportunity appears, on the Lee National Forest for investigation of natural reproduction, methods of cutting, thinning, slash disposal, and effect of fire. Study to be conducted by C. F. Korstian and A. L. MacKinney. During the extensive survey attention will be given to the formulation of a program for Coastal Plain work and to the location of additional branch stations.

NATURAL REPLACEMENT OF CHESTNUT. Examinations to be made of previously established plots and quadrats, and new plots to be established by C. F. Korstian and A. L. MacKinney.

BENT CREEK DEMONSTRATION FOREST. A management plan to be made of the tract, by E. H. Frothingham, C. F. Korstian, and J. H. Buell.

THINNINGS IN THE BILTMORE ESTATE. The permanent sample plots are to be re-measured, and, if necessary, thinned for the third time after the growing season of 1928. Assigned to E. H. Frothingham and other members of the staff. A report on the results to date to be prepared in 1929.

THINNINGS IN MOUNTAIN SECOND-GROWTH. Plots on Kagle Mountain, near Bent Creek, to be completed. No other work planned. Assigned to E. H. Frothingham and F. W. Haasis.

#### B. Protection - fire

FOREST FIRE DAMAGE. Report on physical damage phase of the study to be completed by E. F. McCarthy, and a new phase, damage to forest soils, to be started by C. R. Hursh. The study will consider the influence of forest fires in the mountain region upon (a) the physical structure of the soil, (b) the transformation of organic matter and nitrogenous compounds, together with the influence of fire upon biological activities in the soil, and (c) the mineral constitution of the soil and its buffer reactions.

FOREST FIRE WEATHER. Continuation of previous work with special reference to inflammability of forest fuels, to be undertaken by C. R. Hursh. This study will relate closely to the preceding in many respects.

#### C. Tree studies

THE OAKS. One man from the Appalachian Station will be assigned to cooperate with the Central States Station in the continuation of volume and yield studies of the oaks.

#### D. Forest mensuration

GROWTH SAMPLE PLOTS. Study to be continued by Frothingham and Haasis. Plots to be established in young stands as opportunities are met with by the permanent sample plot party assigned to the hardwood methods of cutting study.

### E. Utilization

MILL SCALE STUDY IN THE MOUNTAIN REGION. A member of the Station staff will participate in the study to be undertaken by the Forest Products Laboratory, the eastern administrative district of the Forest Service, and cooperators in forest pathology and entomology.

### F. Forestation

TESTS OF SPECIES FOR PLANTING IN THE SPRUCE-FIR TYPE. Continuation of the planting experiments on Clingman's Peak, conducted by C. F. Korstian. Some seed to be sown in the Champion Fibre Company's nursery, for the production of planting stock of promising species for future tests.

TESTS OF SPECIES IN THE HARDWOOD TYPES. Continuation of experimental plantings at Bent Creek or elsewhere, to be conducted by C. F. Korstian. Artificial restocking of heavily cut-over areas to be tried, with special reference to areas cut for chestnut. Experiments in sowing yellow poplar seed and in raising seedlings for planting to be continued.

GENERAL STUDY OF PLANTATIONS. Records to be made of plantations met with in course of other work. Permanent plots to be established where conditions are especially favorable as at working centers. Assigned to F. W. Haasis.

### G. Weather

EFFECTS OF THE 1925 DROUGHT. Plots established in 1925 to be reexamined, and a report to be prepared by F. W. Haasis in the winter of 1928-9.

### Studies in forest pathology

These are continuations of studies by the Office of Forest Pathology in the Southern Appalachian region.

CHESTNUT BLIGHT SURVEY AND INSPECTION OF RESISTANT TREES. To determine the rate of spread of the blight and the resistance of exotic and hybrid trees.

TANNIN STUDIES. Determination of tannin content of chestnut trees dead for different lengths of time, from 5 to 30 years.

CHESTNUT SPROUT, FELLING, AND GIRDLING EXPERIMENTS. To determine rate of sprouting, mortality of sprouts from blight, and to compare rate of deterioration between girdled, felled, and check chestnut trees.

ORNAMENTAL AND SHADE TREE DISEASES: Causes, distribution, and severity.

STUDY OF HEART ROTS IN OAKS. Determination of the macroscopic, microscopic, and cultural characters of the heart rots of oak, with their causal organisms.

DETAILED STUDY OF THE ENTRANCE OF FUNGI, THROUGH FIRE SCARS IN OAK. Two parts: (a) scars in standing trees due to forest fires, and (b) artificially made scars. Part (a) involves establishment and periodic examination of permanent sample plots on burned north and south exposures. Burns from 1 to 10 years old and older should be studied for data on: checking of bark of the burned parts of trees; time elapsing before the bark has fallen away sufficiently to expose the wood; amount, depth, and time of checking of the exposed wood; and effect of climatic and other factors upon the above mentioned points. Part (b) is designed to trace the mycologic and entomologic succession and progression by means of artificial scars, periodically examined. Scars should be made on north and south sides of small and large trees, some screened against insects, others unscreened. Some study must be made of the mechanics of the production of artificial scars.

#### Studies of forest insects

These studies are being conducted by the Division of Forest Insect Investigations in cooperation with the Appalachian Station.

SOUTHERN PINE BEETLE. A bulletin on this beetle has been prepared and put into manuscript form by R. A. St. George and J. A. Beal. The interrelation of blue stain fungi and the southern pine beetle, a joint problem with Pathology, will be undertaken. Further studies will be made on natural factors affecting beetle abundance. Studies of reproduction following thinning by beetles will be carried further.

INSECTS IN RELATION TO FIRE: Cooperative work with the Bureau of Plant Industry on insects and fungi attacking fire scars will be continued. Relation of insects to fire and subsequent effect on insect development will receive much attention.

LOCUST BORER: Further studies on artificial and silvicultural control will be made.

TREE INJECTION: The control of obnoxious insects by tree injection will be followed intensively.

PROTECTION OF FELLED LOGS: A proposed study to be renewed in 1928. Several tar products will be tested against insects.

#### All-Service Projects

PREPARATION OF MANUALS ON SILVICAL RESEARCH METHODS. Conducted by E. N. Munns, for the Washington Office, in collaboration with the various forest experiment stations. A manual on permanent sample plots to be completed, and one on field technique to be prepared.

PRESENT AND POTENTIAL GROWTH AND YIELDS OF THE FOREST REGIONS OF THE UNITED STATES. A current project at all of the forest experiment stations in connection with the more intensive studies of growth and yield and observations of forest conditions.

Active Projects in Order of Importance\*

1. Methods of cutting and natural reproduction - hardwoods (Mc-2).
2. Reproduction, growth, and management of loblolly pine (M-111).
3. Natural replacement of chestnut (M-3).
4. Bent Creek demonstration forest (M-Station forest).
5. Forest fire damage: soils (Pf-A-1).
6. ~~Forest fire weather: inflammability of litter (Pf B-2)~~.
7. The oaks: growth and yield (TS-12).
8. Thinnings: Biltmore Estate (Mt-1).
9. Growth sample plots (ME-1).
10. Mill scale study: mountain region (RPL,L-260-2)
11. Tests of species: planting in the spruce type (Fp-3).
12. Tests of species: planting in hardwood types (Fp-4).
13. Thinnings: mountain second-growth (Mt-2).
14. Effects of the 1925 drought (Pw-1).
15. General study of plantations (Fp-2).

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\*"Importance" based upon estimated amount of time and number of men to be given the projects in 1928. Projects in forest entomology, pathology, and biology are not included in this list.

## PERMANENT SAMPLE PLOTS

Location and Purpose	Plot No.	Size (acres)	Treatment	Established	Next Exam.
Asheville Branch					
Bent Creek					
Planting tests	A 1-11	Various	Planted	1926 - 7	1928
" "	B 1- 2	.1	"	1926	1928
" "	C 1- 3	.1	"	1926	1928
" "	D 1- 3	Various	"	1926 - 7	1928
" "	E 1- 2	"	"	1927	1928
Hd'wd. reproduction	3	.25	Burned & cut-over	1925	1930
" "	4	.15	Cut-over	1925	1930
Chestnut replacement	6	1.00	" "	1927	1930
" "	7	1.00	" "	1927	1930
" "	8	1.00	Control	1927	1930
" "	9	1.00	"	1927	1930
" "	10	1.00	Cut-over	1927	1930
" "	11	.50	" "	1927	1930
" "	15	.50	" "	1927	1930
" "	1-40	1/160 ea.	None	1927	1928
Biltmore Estate					
Thinnings - pine	1 a	.250	Thinned	1916	1929
" - "	1 b	.125	Control	1916	1929
" - "	1 c	.125	"	1916	1929
" - "	2 a	.100	Thinned	1916	1929
" - "	2 b	.100	Control	1916	1929
" - maple	3 a	.050	Thinned	1916	1929
" - "	3 b	.050	Control	1916	1929
" - pine	4 a	.125	Thinned	1916	1929
" - "	4 b	.080	Control	1916	1929
Mount Mitchell					
Planting tests	A 1-23	.10ea	Planted	1923 - 7	1928
" "	B 1-28	.10"	"	1923 - 7	1928
" "	C 1	Irreg.	"	1925	1928
" "	D 1- 2	.07	"	1926	1928
" "	E 1- 2	.07	"	1926	1928
Curtis Creek					
Hd'wd reproduction	1	.25	Cut-over	1922	1928
" "	2	.25	" "	1922	1928
Growth, young stands	3	.40	None	1926	1928
" " "	4	.40	"	1926	1928
Harper's Creek					
Fire damage	1	.50	Burned 1926	1926	1928
" "	2	.60	" "	1926	1928
" "	3	.60	" "	1926	1928
Pritchard Creek					
Fire damage	1	3.00	Burned 1922	1923	1928
" "	2	1.00	" "	1923	1928
" "	3	1.25	" "	1923	1928
" "	4	1.25	" "	1923	1928

CONT'D.

## Asheville Branch

	Plot No.	Size (acres)	Treatment	Established	Next Exam.
Lookingglass Rock					
Hd'wd. reproduction	1	.5	Control	1923	1928
" "	2	.5	"	1923	1928
" "	3	.5	Liberation	1923	1928
" "	4	.5	"	1923	1928
Berea Branch					
Berea College Forest					
Hd'wd. reproduction	1	2.8	Cut-over	1923	1928
" "	2	.5	Control	1923	1928
" "	3	3.5	Cut-over	1923	1928
" "	4	1.0	Control	1923	1928
Growth, young stands	5	.5	None	1926	1928
" "	6	.5	"	1926	1928
Edinburg Branch					
North Mountain					
Hd'wd. reproduction	1	1.05	Cut-over	1924	1929
" "	2	.50	Control	1924	1929
" "	5	.50	Cut-over	1924	1929
" "	6	.25	Control	1924	1929
" "	8	1.00	Cut-over	1927	1932
Chestnut replacement	9	1.00	" "	1927	1932
Thinnings - hd'wds.	3	.50	Thinned	1924	1929
" "	4	.33	Control	1924	1929
" "	7	1.00	Thinned	1927	1932
Hone Quarry					
Hd'wd. reproduction	3	.50	Cut-over	1923	1929
Beaver Dam, Va.					
Page Estate					
Thinnings - pine	1	.250	Thinned	1913	1930
" "	2	.250	"	1913	1930
" "	3	.125	"	1913	1930

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